02/03/1997

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ARCO

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Los Angeles, California 90071
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Richard A. Elliott
Project Manager
Environmental Remediation

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Compliance & Environmental
Justice

February 3, 1997

Mr. Mark Walker
CDPHE/Hazardous Materials and
Waste Management Division
4300 Cherry Creek Drive South
Denver, CO 80222-1530

Dear Mr. Walker:

Enclosed is a copy of the Rico Mining Area Construction Completion Report covering the Argentine Tailings, Columbia Tailings, Silver Swan Mine, Santa Cruz Mine, Shamrock Tailings, Pro-Patria Tailings, and the Grand View Smelter. Periodic reports will be issued to document the site inspections and the water quality monitoring per the VCUP Applications.

If you have any questions, please call me at 213/486-2475.

Sincerely,

Richard A. Elliott

Richard A. Elliott

Enclosures: 1

cc: Cindy Kezos

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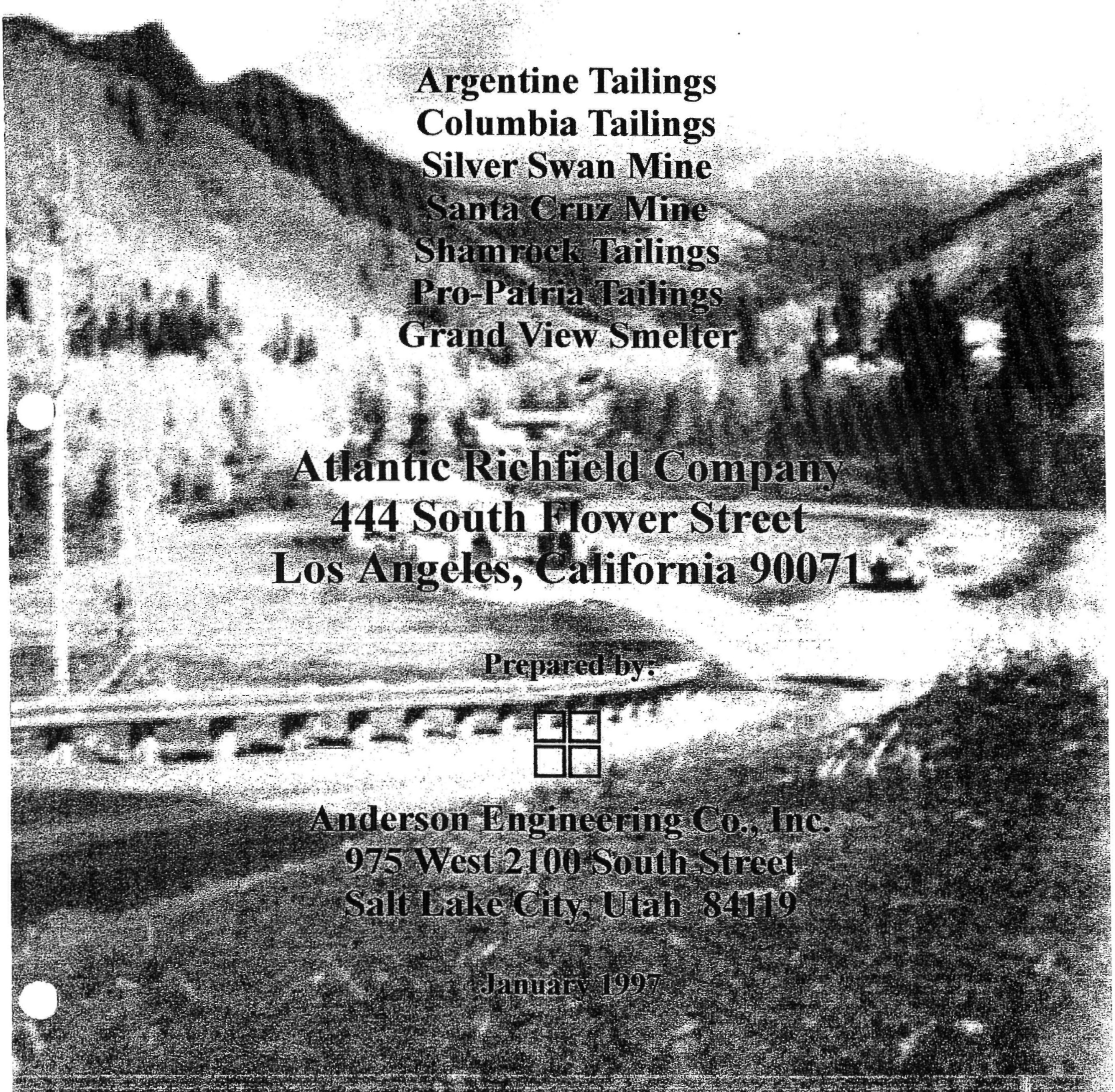
HAZARDOUS MATERIALS
AND WASTE MANAGEMENT

ARCO

Rico Mining Area
Construction Completion Report



Argentine Tailings
Columbia Tailings
Silver Swan Mine
Santa Cruz Mine
Shamrock Tailings
Pro-Patria Tailings
Grand View Smelter

Atlantic Richfield Company
444 South Flower Street
Los Angeles, California 90071

Prepared by:

Anderson Engineering Co., Inc.
975 West 2100 South Street
Salt Lake City, Utah 84119

January 1997

ARCO

Rico Mining Area
Construction Completion Report

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Rico Mining Area
Construction Completion Report

Table of Contents

Table of Contents (con't.)

Section **Page No.**

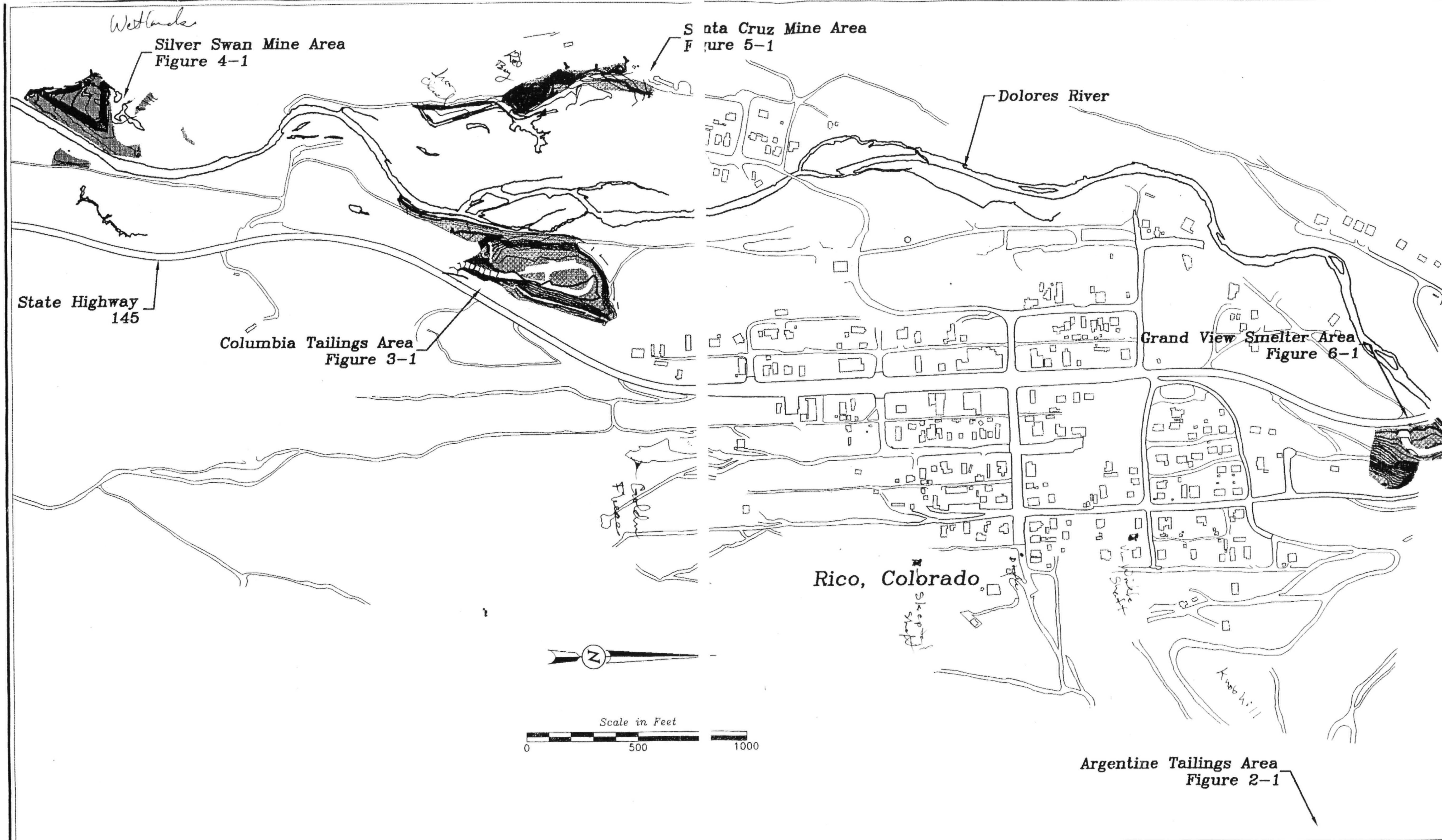
Table of Contents (con't.)

Section **Page No.**

Table of Contents (con't.)

List of Tables

List of Tables (con't.)



ATLANTIC RICHFIELD COMPANY
RICO MINING AREA
CONSTRUCTION COMPLETION REPORT

ANDERSON ENGINEERING CO., INC.
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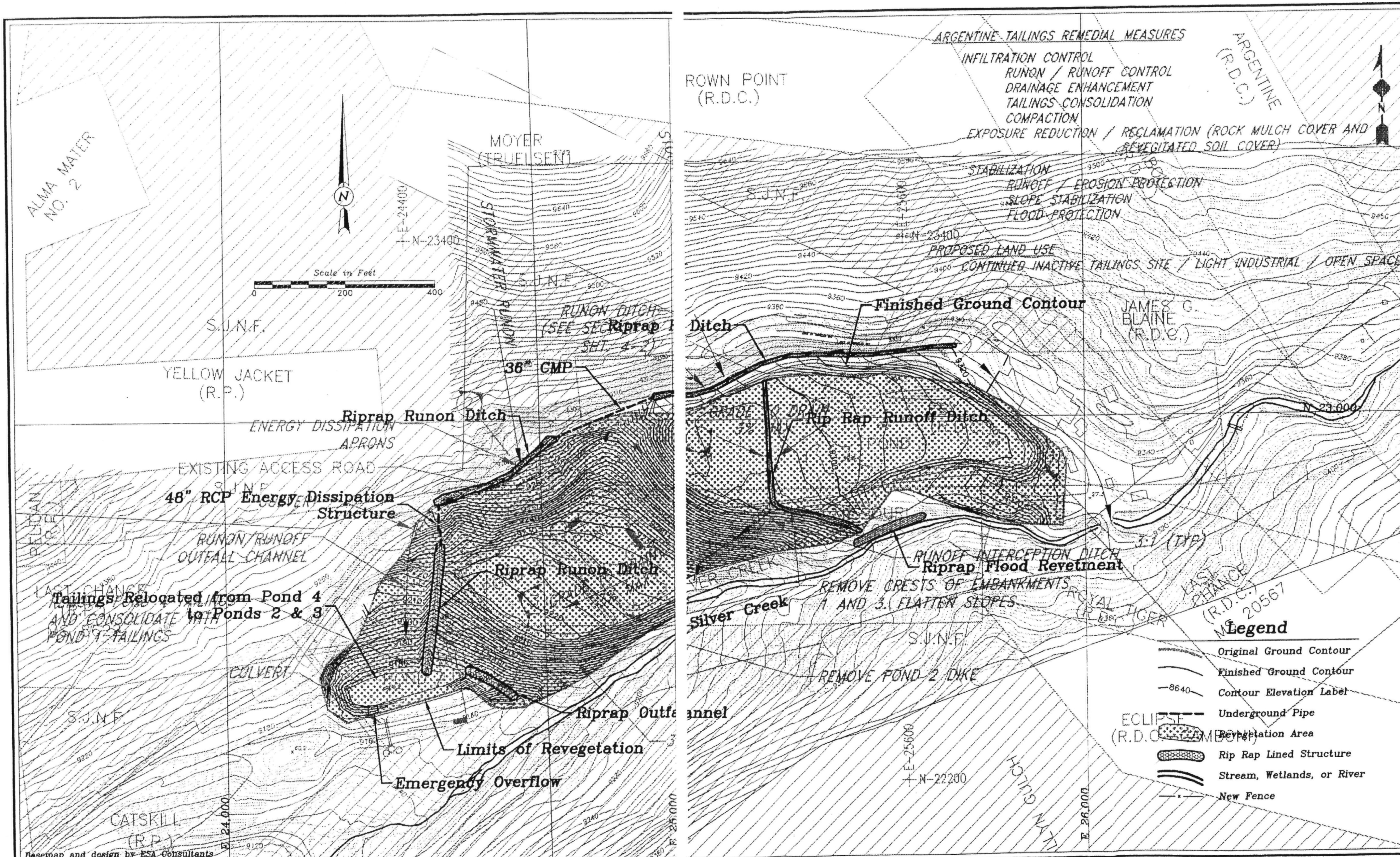
SCALE:	1" = 400'
OTHER REFS:	.

PROJECT BASE MAP AND SHEET INDEX

References:

FIG. 1-1

File: RICOTOWN.DWG view (plan)



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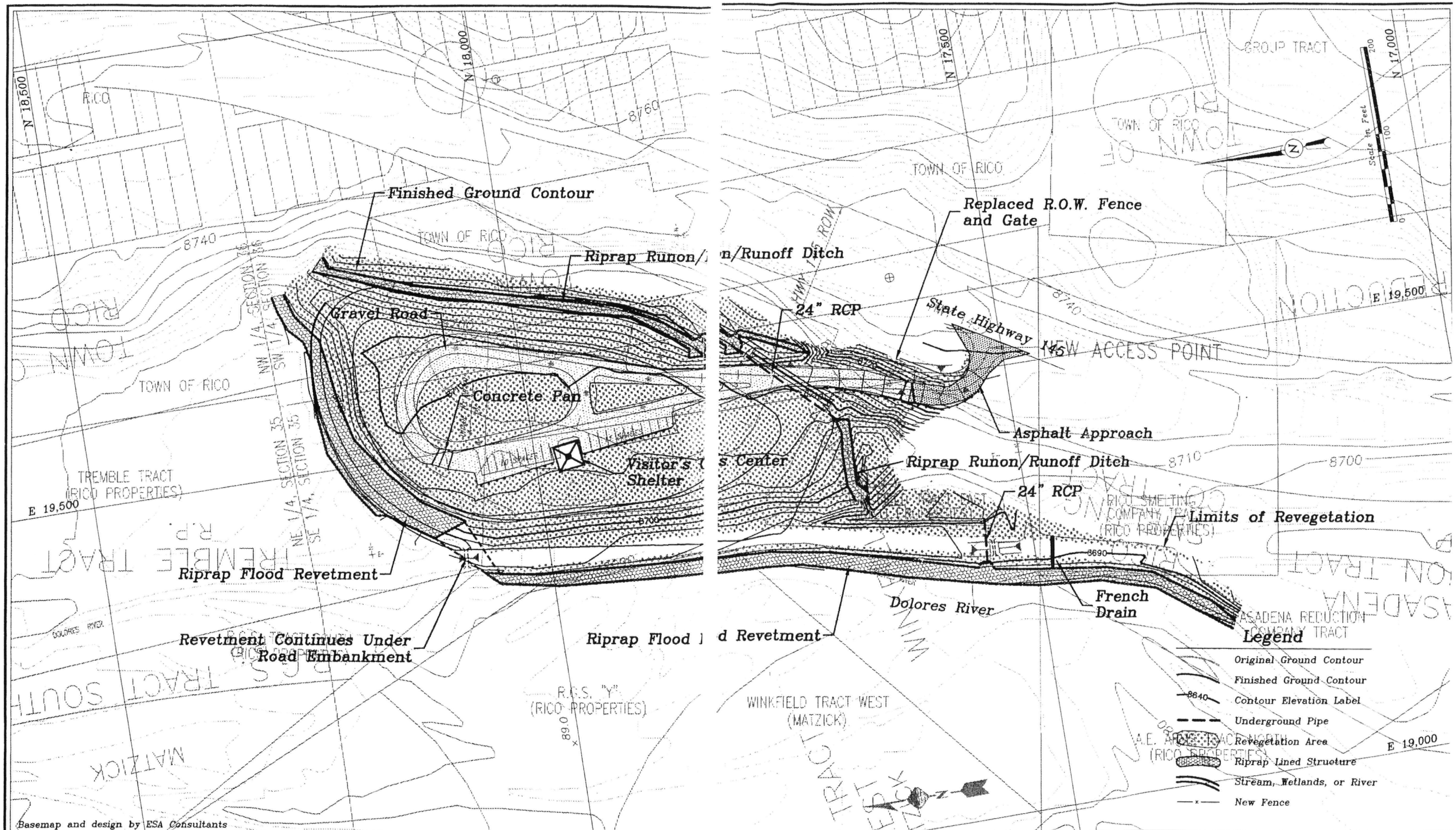
OTHER REFS:	ar_prop.dwg

ARGENTINE TAILINGS AREA FINAL CONFIGURATION PLAN VIEW

References: arconcep.dwg ar-econt.dwg

FIG. 2-1

File: ARG.DWG view (plan)



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OTHER REFS:	sc_econt.dwg

COLUMBIA TAILINGS AREA
FINAL CONFIGURATION PLAN VIEW

References: scconcep.dwg sc_prop.dwg

FIG. 3-1

File: COLUMBIA.DWG view (plan)

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SILVER SWAN MINE AREA FINAL CONFIGURATION PLAN VIEW

References: ss-econf.dwg ssconcep.dwg

FIG. 4-1

File: SLVRSWN.DWG view (plan)

List of Figures

Rico Mining Area
Construction Completion Report

1.0 Project Summary

1.1 Background

The Rico mining area is located in southwest Colorado between Cortez and Telluride along the Dolores River. The site includes former silver, lead and zinc mines, and milling and smelting operations that are located around the town of Rico. The priority mining and milling areas are shown in Figure 1-1. These locations have varied ownership histories and reclamation needs.

The International Smelting and Refining Company, an Anaconda subsidiary, had an ownership interest in a company which owned the Pro Patria Mill and other mining properties in the area. The Rico Argentine Mining Company built a mill along Silver Creek in the late 1930's. In the early 1980's Anaconda, a division of Atlantic Richfield Company (ARCO), controlled about 7,500 acres in the Rico area, and implemented a drilling program for molybdenum. At this time hazard elimination work was completed by Anaconda. In 1988 Anaconda sold its property located around the Rico area to Rico Development Corporation. The property has since been divided and sold to several parties for development.

1.2 Voluntary Cleanup

Prior to remediation the Rico mining area had various environmental concerns that include eroding mine waste, mine water discharge, water seeps from waste piles and various remnants of ore processing facilities.

The State of Colorado passed into law the Voluntary Cleanup and Redevelopment Act (HB94-1299) which provides a mechanism for owners and cooperating parties to take action to address human health and environmental concerns, and promote redevelopment and reuse of disturbed lands. The property owners of the particular mining or milling area, in cooperation with ARCO, submitted applications to the State of Colorado Department of Public Health and Environment under the Voluntary Cleanup and Redevelopment Act (VCRA) to address reclamation, human health and environmental concerns of the Rico priority sites. Following is a list of the VCRA applications made and submitting parties:

Cleanup activities began on July 1, 1996 and were completed by November 13, 1996. The work accomplished under the VCRA permits for the Argentine, Columbia Tailings, Santa Cruz Mine, Silver Swan Mine, and Grand View Smelter Site included:

- Removal of waste rock and tailings material from active waterways and drainages.
- Reconfiguration, consolidation and stabilization of waste rock and tailings piles to minimize erosion and eliminate slope instability.
- Implementation of source controls to reduce the generation or transport of dissolved metals.
- Provide capping and erosion protection to effectively minimize the potential for direct human health exposure to the mill tailings and mine waste rock.
- Construct passive treatment features to reduce current metal loadings from adit discharge to receiving waters.

2.0 Argentine Tailings

How much is on FS land?
Did they approve?

2.1 Site History

The Argentine Site is located on the north side of Silver Creek approximately 0.6 miles northeast of the town of Rico. Since 1938, the Site area has been occupied by a flotation mill, and mine and tailings disposal facilities. The Site covers approximately 15 acres.

2.2 Permit

The VCRA application, Revision 1 dated February 5, 1996 and supplemental information to the application dated March 19, 1996 were approved by the CDPHE on March 20, 1996. The CDPHE approval stated that the VCUP would meet a degree of cleanup and control of hazardous substances such that the property does not present an unacceptable risk to human health or the environment based on the property's proposed use as an open space. The approved VCUP remedial design for the Argentine Tailings Site involves shaping of tailings pond outslopes to control erosion, consolidation of Pond 4 materials into Ponds 2 and 3, grade the area to route upland surface water around the tailings wastes for runon control, and surface adjustments and compaction to shed rainfall and snowmelt from the tailings to control erosion and limit infiltration. The VCUP also calls for providing erosion protection through placement of growth medium and revegetation.

2.3 Geohazards

The natural hazards that may have been expected and could require attention at the Argentine Tailings are flooding and seismicity. No substantial natural hazards were encountered during construction. Caution was taken during slope modification of Pond 1 to avoid slimes tailings movement and slope instability. Grading plan modifications were made to deal with soft slimes during slope recontouring of Pond 1. Silver Creek flows did not constitute any excavation problems above those expected, however, some repairs were made for erosion protection along the Silver Creek channel.

2.4 Site Access

Access to the Argentine was by existing roads which cross both private and National Forest lands. All roads were maintained and left in as good or better condition than existed prior to their use on this project. Site access ways were maintained in compliance with the USFS Special Permit.

2.5 Construction Site Controls

Controls were implemented during construction to address requirements of applicable federal, state or local permits, codes or regulations. All construction and specifications employed appropriate Best Management Practices to protect Silver Creek from sedimentation during remedial activities. Temporary berms to control runoff to Silver Creek were constructed in work or active traffic areas. Silt fencing and hay bales were used as barriers to prevent sediment migration into Silver Creek during excavation activities. Also, construction activities were conducted in a manner to preserve existing vegetation buffers in the work areas. Runoff water from disturbed areas was retained for settling of sediments prior to allowing discharge into Silver Creek. Strict precautions to avoid dust and excavation spillage during operations were followed by the use of water spray and control of load heaping on haul units.

The onsite construction activities were conducted in strict compliance with the VCUP, Site Specific Safety and Health Plan and Site Pre-Excavation Construction Plans as well as regulatory permits obtained for the specific work area.

2.6 Hydraulic Controls

2.6.1 Runon

maintenance? by whom?

The runon generated from rainfall or snowmelt upland of the Site is directed away from the Argentine Tailings reclaimed tailings ponds by a 1700 linear foot lined runon ditch. The runon ditch was excavated into the natural ground surface north of the Site, adjacent to the existing access road. Stormwater is directed under the road by a culvert and into an erosion resistant outfall channel to convey flows around Pond 3 and through the former Pond 4 area. Pond 4 was cleaned of residual tailings and the area used as a retention site for runon water prior to spilling into Silver Creek. Figure 2-1 shows the alignment of the runon ditch.

The runon ditch consists of a combination of riprap lined channel, corregated metal pipe (CMP) and a reinforced concrete pipe (RCP) energy dissipation drop structure. From the start of the ditch at the Pond 4 area to the drop structure is a trapezoidal designed channel built with Type A riprap (as defined in Section 2.8.2) about 2.4 ft. thick laid over 6 inches of Type D and 6 inches of Type E bedding. All bedding in the riprap lined ditches was placed over 60 mil high density polyethylene (HDPE) textured liner. The energy dissipation drop structure was constructed of 42 inch concrete and is approximately 180 feet in length. This structure handles runon flows from the upland areas to the north collected in the ditch and passes this flow to the lower elevation near the Pond 4 area. Extending about 250 ft. to the northeast is a "v" notch ditch lined with Type C riprap averaging 1.2 ft. thick over 6 inches of Type E bedding and HDPE liner. Where the runon ditch closely parallels the road north of the Argentine Tailings, a 36 inch CMP was placed for a distance of 250 ft. to carry flows beneath the road and to maintain a minimum 20 ft. road weight. The CMP is constructed with a grouted riprap inlet and outlet. The runon ditch upgradient of the CMP extends for 770 feet. This final reach of the runon ditch is constructed of Type D riprap placed over HDPE textured liner.

Water that collects in the Pond 4 retention area is released to Silver Creek by a spillway and outfall channel. The outfall channel from the Pond 4 area conveys runon waters down the south slope into Silver Creek. The outfall channel is a 40 ft. wide riprap trapezoidal spillway that moves water down slope at a 4h:1v angle. The riprap placement was constructed similarly to that of the runon ditch between the drop structure and the Pond 4 area. The outfall channel discharges flow onto the existing river rock material along Silver Creek. A riprap lined emergency spillway is located at the southwest end of the Pond 4 retention area.

2.6.2 Runoff

The top surfaces of Tailings Ponds 1, 2 and 3 have been shaped to drain precipitation and not retain runoff on the reclaimed surface. The surface grade of Ponds 2 and 3 is generally to the southwest at 3%.

The surface of Pond 1 was graded to direct runoff flows at about 3% to the runoff ditch from the east and west segments of the Pond. The runoff ditch at the Argentine Tailings was constructed as a drainage swale in the central portion of Pond 1. The runoff ditch drains to the south and follows the outslope contour to more gradually drop water into Silver Creek. The flow area of the runoff ditch is lined with a textured liner (60 mil HDPE) and is also riprap lined with 6 inches of Type B erosion protection riprap. The runoff ditch was constructed to a width of 6 ft. and is 1.0 ft. deep. The runon and runoff ditches are sized to pass peak flows for a 100 year precipitation event. Figure 2-1 shows the runoff ditch location.

Outslopes of the reconfigured tailings ponds are 3h:1v slopes and drain runoff water into the Silver Creek watershed.

2.6.3 Infiltration

Infiltration of water into the tailings ponds at the Argentine Tailings Site is controlled by rerouting runon away from the reclaimed areas, reducing the surface area of the tailings, regrading of the tailings to prevent the ponding of water and compaction of the top surface of the reclaimed tailings to impede infiltration.

The rerouting of runon and runoff away from the tailings will significantly reduce infiltration. The runon water contribution to the tailings areas has been eliminated by the newly constructed runoff ditches.

Pond 4 material was removed and consolidated into Ponds 2 and 3. The surface area of the tailings pile has been reduced by 13%, therefore reducing the infiltration surface available. The total area of the tailings was reduced by 1.3 acres, leaving a total of 10 acres of surface. The tailings were consolidated by excavation of the tailings material from Pond 4, hauled and placed as compacted cover over the surface of Ponds 2 and 3.

The upper 18 inches of top surface and outslopes of the Argentine Tailings pile were compacted to reduce infiltration. With the material types encountered in the tailings, the density that is achieved by this compaction will reduce the hydraulic conductivity. The results of compaction testing conducted on the Argentine Tailings reconfigured surface are summarized in Section 2.10.

2.6.4 Drainage Stabilization

Flood plain delineation?

where did the sediment go?

The Argentine Tailings Ponds are adjacent to Silver Creek and may be susceptible to seasonal flooding. Flood protection work was completed in 1981 and 1982 by Anaconda at the tailings pond slope toe along Silver Creek using grouted riprap. The erosion protection in place is in good condition, and minor repairs were completed to enhance protection. Some of this area had experienced minor undercutting by Silver Creek during periods of high flow. Repairs involved placement of a riprap revetment at the toe of Pond 1 along the Silver Creek as shown on Figure 2-1. The revetment length is about 125 feet and consists of Type A riprap (see Section 2.8.3 for description).

2.7 Waste Materials

2.7.1 Consolidation

The tailings material from Pond 4 at the Argentine Tailings was relocated to Ponds 2 and 3. Approximately 10,500 cubic yards of tailings were relocated and shaped to meet the lines and grades presented in the VCUP. This work was accomplished using bulldozers, wheel loaders and highway type trucks. The removal location of the tailings and the final graded surface of the area are shown on Figure 2-1.

See copies?

Tailings were removed in layers of about 12 inches in thickness. Following removal, confirmatory sampling was conducted to detect if all tailings material had been removed. This process was repeated until conformation sampling showed that no additional material removal was required.

Verification of tailings removal was accomplished by collecting confirmatory samples of the underlying alluvium. Waste rock excavation was considered completed, as defined in the VCUP, when the Zinc content fell within or below the range ~~of local natural bedrock~~ and surficial materials. This range is 200 to 4720 ppm Zinc. The sampling of the removal areas confirms that

what samples where?

over 50% ?

the majority of tailings was excavated from the areas of concern. Sampling ~~results and summaries~~ for the Argentine removal are contained in Section 2.10.2.

compaction evaluation ?

Relocated wet tailings were spread thinly and filled until moisture conditions of the material allowed for compaction. The relocated tailings were placed onto Ponds 2 and 3 in lifts not exceeding 12 inches in depth. The compaction effort was accomplished by placement equipment making a minimum of one pass over the entire surface of each 12 inch lift. Tailings placed in the upper 12 inches of the top surface, but below the lime amended area, were compacted as previously discussed.

2.7.2 Surface Shaping and Slopes

what is the v/h slope of embankment ?

The top surface of the consolidated tailings on Pond 1 drains to the swale runoff ditch at a 3% grade. Ponds 2 and 3 are graded to drain runoff to the southwest. The tailings have been reconfigured with the outslopes draining the Site. Although the outslopes vary in length from about 150 ft. to about 220 ft., all are constructed to a 3h:1v geometry. An intermediate slope exists between Pond 1 and Pond 2, and between Pond 3 and Pond 4, the area that has been graded to 3h:1v. Due to the extremely wet conditions and slime tailings encountered in grading the Pond 1 slope, the configuration was modified. The slope crest was moved and the slope toe extended to use a fill approach rather than a cut and fill as originally planned. Fill was obtained from the Argentine Borrow Area and from adjacent land shaping activities. The reconfigured Argentine Tailings was graded to a tolerance of ± 0.3 ft. of construction drawings and free of irregularities. Figure 2-1 shows the preexisting conditions, VCUP configuration and the as built conditions of the Argentine Tailings.

2.8 Erosion Protection

2.8.1 Growth Medium

sample results ?

Growth medium material comprises compacted surface tailings and soil cover. The top surface of the reshaped Argentine Tailings was sampled to determine agricultural lime ($CaCO_3$) requirements for plant establishment. Areas requiring agricultural lime amendment and areas where lime total lime?

amendment was unnecessary were delineated in the field. The lime was applied at a rate of 200 tons/acre to the upper 6 inches of compacted tailings. Table 2.1 shows the lime application rates by area for the Argentine Tailings. The lime was spread evenly over the Site by mechanical methods then incorporated. Multiple tilling passes were made to insure complete mixing of the lime into the material. The liming process was accomplished immediately following waste pile shaping to provide the greatest reaction time prior to revegetation. The amended layer was re-compacted prior to placement of soil cover material.

Borrow soil used for plant growth, also referred to as rock mulch, was tested and identified prior to excavation. The borrow soil was obtained from the Argentine borrow area 0.2 miles from the Argentine Tailings. The soil was transported by truck to the Argentine Tailings, placed on the top surface and slopes, and covers the entire areal extent of the regraded waste pile. Soil cover application rates by area are listed in Table 2.1. The traffic over the soil was kept to a minimum to avoid unnecessary compaction of the seed bed. The finished grade for the soil growth medium is ± 0.3 ft. of design and contains no irregularities.

Table 2.1
Argentine Tailings
Agricultural Lime and Cover Material Application Rates

SITE AREA	LIME APPLICATION RATE FOR TAILINGS	SOIL COVER APPLICATION RATE
Pond No. 1	200 tons/acre (1.1 in. thick) Amended 6 inches deep and compacted. (Approx. ½ of Pond 1 was lime amended).	6-inch rock mulch cover.
Pond Nos. 2 and 3 Tailings Removal Area	No lime.	24-inch rock mulch cover.
3:1 slope between Pond Nos. 1 and 2.	200 tons/acre (1.1 in. thick) Amended 6 inches deep and compacted. (Approximately 1/3 of the slope was lime amended).	12-inch rock mulch cover above elevation 9245. 24-inch rock mulch cover below elevation 9245.
3:1 slope between Pond Nos. 3 and 4.	200 tons/acre (1.1 in. thick) Amended 6 inches deep and compacted. (Approximately 2/3 of the slope was lime amended).	12-inch rock mulch cover.

2.8.2 Revegetation

All seed was applied using hydroseeding methods due to wet surface conditions and time constraints. Table 2.2 contains seed mixtures and applications used at the Argentine Tailings. The hydroseeding and fertilization sequence of activity completed is as shown on Table 2.3. Mulch was also spread by hydro application methods and held in place by tacking agents.

Table 2.2
Seed Mixtures and Application Rates

Type A (1) General Seed Mixture			
Species	**Preferred Variety(s)**	**Rate (lbs./acre) Planted (broadcast)**	**PLS (seeded/acre)**
Big bluegrass Poa ampla	Sherman	0.50	458,500
Mountain brome Bromus carinatus	Bromar	8.00	496,000
Slender wheatgrass Agropyron trachycaulum	Primar, San Luis	3.00	480,000
Streambank wheatgrass Agropyron riparium	Sodar	3.00	480,000
Birdsfoot trefoil Lotus corniculatus	Empire	1.00	410,000
Lewis flax Linum lewisii	Apar	2.00	570,000
Rocky Mountain penstemon Penstemon strictus	Bandera	1.00	592,000
Cicer milkvetch Astragalus cicer	Lutana, Monarch	1.50	290,000
	Totals	**20.00**	**3,776,500 (approx. 87 seeds per square foot)**

(1) Applied on lower portion of Pond No. 1 west slope, on consolidated Pond Nos. 2 and 3, and on Pond No. 4, except embankment slope.

Type B (2)
Sideslope Stabilization Mixture

Species	Preferred Variety(s)	Rate (lbs./acre) Planted (broadcast)	PLS (seeded/acre)
Big bluegrass Poa ampla	Park	0.50	1,100,000
Mountain brome Bromus carinatus	Bromar	15.00	975,000
Slender wheatgrass Agropyron trachycaulum	Primar, San Luis	6.00	960,000
Streambank wheatgrass Agropyron riparium	Sodar	6.00	960,000
Cicer milkvetch Astragalus cicer	Lutana, Monarch	1.50	290,000
	Totals	**29.00**	**4,285,000 (approx. 98 seeds per square foot)**

Type C (3)
(Acid-Tolerant Mixture)

Species	Preferred Variety(s)	Rate (lbs./acre) Planted (broadcast)	PLS (seeded/acre)
Hard Fescue Festuca ovina var. duriuscula	Durar	2.00	1,130,000
Orchardgrass Dactylis glomerata	Latar	2.00	1,080,000
Tall fescue Festuca arundinaceae	Alta	5.00	1,135,000
	Totals	**9.00**	**3,345,000 (approx. 77 seeds per square foot)**

(2) Type B applied on Pond No. 1 access road side slope and Pond 4 embankment slope.
(3) Type C applied on majority of Pond No. 1, except as noted above.

Table 2.3
Argentine Tailings
Revegetation Sequence

Item	Seed Bed Preparation	Fertilizer	Seed	Mulch
Period	Prior to fertilization and seeding.	Concurrent with seeding.	After September 30th, immediately following final seed bed preparation.	Immediately following seeding.
Method	Mechanical scarification of soil.	Combined with hydroseeding Liquid fertilizer mixture.	Hydroseeding on all areas.	Hydromulch - 1500 lbs./acre, all areas. Slurry pH> - 3.5.
Equipment	Disc or rippers pulled by tractor.	Mobile hydroseeding equipment.	Mobile hydroseeding with spray and tank equipment.	
Discing/Raking	Disc or rip to 12 inch depth maximum.			
Other	Insure adequate seed bed without hard surface resistant to seed placement.	Nutrient application applies to all sites: Nitrogen (lb./acre): 40 Phosphate (lb./acre): 60 Potash (lb./acre): 40	Type A General seed mix (<3:1) B Side slope mix (>3:1) C Acid-tolerant mix	Purpose: twofold: 1. Conserve water 2. Deter erosion

Note: Ripping of final graded surface completed prior to broadcasting fertilizer. Ripped to a maximum depth of 12 inches.

2.8.3 Riprap

Rock erosion protection was placed in areas where runoff, runon and drainage way flows were considered to be highly erosive. Riprap types and bedding are shown on Table 2.4.

Table 2.4
Argentine Tailings
Riprap and Bedding

		Percent Passing					
Type	**Description**	**100**	**85**	**50**	**30**	**15**	**0**
A	Riprap	1.7-2.4'	-	1.4'-1.6'	1.2'	0.9'	0.8'
B	Riprap	Larger Rock Material Generated By Borrow Processing					
C	Riprap	0.9-1.2'	-	0.7-0.8'	0.6'	0.5' - 0.65'	0.4
D	Riprap/Bedding	3.0-8.0"	3.0-6.0"	-	-	0.75"- 1.5"	0"-0.5"
E	Filter Material/Bedding	2.0"	0.5-1.5"	-	-	0.5 - 0.65mm	0.6mm

The runon ditch and runoff ditch locations and erosion protection riprap are shown in the plan view on Figure 2-1. These ditches contain bedding, HDPE textured liner and riprap to handle flows resulting from a 100 year precipitation event. These designs are discussed in detail under Section 2.3.

2.9 Quantity Summary

The quantities moved for remedial action for the Argentine Tailings involved nine categories of materials. The total volume of material moved was 56,692 cubic yards. Table 2.5 contains the volume moved by category for earthwork at the Argentine Tailings.

Table 2.5
Argentine Tailings
Relocated Materials, Riprap and Bedding

Activity	Material Type	Units	Quantities	Comments
Relocated Tailings	***	CY	10,506	
Unprocessed Borrow	***	CY	23,700	
Riprap	A	CY	569	
Riprap	B	CY	85	
Riprap	C	CY	193	
Riprap Bedding	D	CY	240	
Riprap Filter Bedding	E	CY	199	
Growth Medium		CY	21,200	(Also called Rock Mulch)
Textured Liner		$Yd.^2$	1,206	plus 510 @ runoff ditch

2.10 Soil Testing Summary

2.10.1 Geotechnical Testing

Field soil density testing was conducted to determine compliance with the technical specifications of the construction contract. The technical specifications relating to compaction were selected to achieve various engineering objectives relating to infiltration and enhancing stability in fill materials. The applicable technical specifications required that the upper 12 inches of the waste piles be of a compactable gradation, and attain 95% of Standard Proctor maximum dry density (or 90% of maximum Providence index density for soils with little or no fines). Table 2.6 summarizes the field soil moisture/density tests conducted for the Argentine Tailings. Nuclear density gauges were used to obtain in-place densities for comparison to laboratory generated Proctor or Providence mold laboratory density tests as appropriate for a given soil. Where moisture/density tests were deficient, footnotes in Table 2.6 indicates the action taken by the field engineer, e.g. - recompaction of the affected area or in cases where additional compaction or replacement of fill materials would not have provided any additional benefits to the long-term performance of the fill with respect to design objectives, no action was directed. Laboratory and field tests were performed and results approved by ARCO. Tests were conducted according to the following standards:

ASTM Method	Description:
Field Tests:	
D-2922	Density of Soil and Soil-Aggregate in Place by Nuclear Methods
Laboratory Tests:	
D-422	Sieve Analysis
D-698	Moisture Density Relationships (5.5 lb. hammer)
D-4253	Modified Providence Moisture Density Relationships

Table 2.6 summarizes the results of field tests.

Table 2.6
Argentine Tailings
Field Soil Testing Summary

Date	Test No.	Location	Density	Moisture	Proctor No.	Maximum Density	Optimum Moisture	Percent Compaction	Notes	% Compaction Required	Percent +\- Moisture
7-Aug-96	AR-NU-01	Ponds 2&3	108.6	13.5%	EF-06-SP-01	123	12%	88%	(1)	95%	1.5%
"	AR-NU-02		119.6	8.4%	"	123	12%	97%		95%	-3.6%
"	AR-NU-03		114.4	9.9%	"	123	12%	93%	(1)	95%	-2.1%
"	AR-NU-04		113.3	12.4%	"	123	12%	92%	(1)	95%	0.4%
"	AR-NU-05		115.3	10.0%	"	123	12%	94%	(1)	95%	-2.0%
"	AR-NU-06		119.1	10.0%	"	123	12%	97%		95%	-2.0%
"	AR-NU-07		119.0	12.2%	"	123	12%	97%		95%	0.2%
"	AR-NU-08		128.6	13.3%	"	123	12%	105%		95%	1.3%
"	AR-NU-09		117.5	16.6%	"	123	12%	96%		95%	4.6%
"	AR-NU-10		121.4	12.7%	"	123	12%	99%		95%	0.7%
8-Aug-96	AR-NU-11	Pond 1 North	101.6	12.5%	EF-05-SP-01	124	9%	82%	(2)	95%	3.5%
"	AR-NU-12		112.6	17.2%	"	124	9%	91%	(2)	95%	8.2%
"	AR-NU-13		133.7	8.7%	"	124	9%	108%		95%	-0.3%
"	AR-NU-14		113.6	14.4%	"	124	9%	92%	(2)	95%	5.4%
"	AR-NU-15		139.5	13.3%	"	124	9%	113%		95%	4.3%
"	AR-NU-16		138.2	7.0%	"	124	9%	111%		95%	-2.0%
"	AR-NU-17		137.0	6.5%	"	124	9%	110%		95%	-2.5%
"	AR-NU-18		138.3	6.5%	"	124	9%	112%		95%	-2.5%
"	AR-NU-19		142.9	6.0%	"	124	9%	115%		95%	-3.0%
"	AR-NU-20		143.2	10.6%	"	124	9%	115%		95%	1.6%

what about stability performance?

(1.) Tested material consisted of tailings slimes removed from Pond 4. The relative impermeability due to the fine-grained nature of this material meets the infiltration performance standards. Therefore, additional compaction effort of the slightly substandard results was deemed to be non-beneficial and was not required.

(2.) Low densities are due to intermixed pockets of saturated tailings slimes. The low permeability of these slimes does not affect the performance of the compacted fill. Therefore, additional compactive effort was deemed to be non-beneficial and was not required.

*Soil testing provided by ESA, Inc, Fort Collins, CO.

Table 2.6
Argentine Tailings
Field Soil Testing Summary

Date	Test No.	Location	Density	Moisture	Proctor No.	Maximum Density	Optimum Moisture	Percent Compaction	Notes	% Compaction Required	Percent +\- Moisture
13-Aug-96	AR-NU-21	Pond 1	137.1	5.1%	EF-05-SP-01	124	9%	111%		95%	-3.9%
"	AR-NU-22		127.6	7.1%	"	124	9%	103%		95%	-1.9%
"	AR-NU-23		107.8	9.5%	"	124	9%	87%	(2)	95%	0.5%
"	AR-NU-24		115.7	11.7%	"	124	9%	93%	(2)	95%	2.7%
"	AR-NU-25		144.1	10.1%	"	124	9%	116%		95%	1.1%
"	AR-NU-26		124.5	12.7%	"	124	9%	100%		95%	3.7%
"	AR-NU-27		132.4	7.3%	"	124	9%	107%		95%	-1.7%
"	AR-NU-28		122.6	5.3%	"	124	9%	99%		95%	-3.7%
"	AR-NU-29		134.7	2.7%	"	124	9%	109%		95%	-6.3%
"	AR-NU-30		111.5	11.0%	"	124	9%	90%	(2)	95%	2.0%
"	AR-NU-31		105.8	16.4%	"	124	9%	85%	(2)	95%	7.4%
"	AR-NU-32		117.8	18.8%	"	124	9%	95%		95%	9.8%
14-Aug-96	AR-NU-33	Pond 1	101.6	17.1%	EF-05-SP-01	124	9%	82%	(3)	95%	8.1%
"	AR-NU-34		107.2	13.3%	"	124	9%	86%	(3)	95%	4.3%
"	AR-NU-35		106.6	10.6%	"	124	9%	86%	(3)	95%	1.6%
"	AR-NU-36		103.4	11.5%	"	124	9%	83%	(3)	95%	2.5%
"	AR-NU-37		114.8	6.6%	"	124	9%	93%	(3)	95%	-2.4%
"	AR-NU-38		104.5	14.7%	"	124	9%	84%	(3)	95%	5.7%
15-Aug-96	AR-NU-39	3:1 Slope - Below Pond 1	115.9	8.6%	"Estimated"	135	***	86%	(4)	90%	
"	AR-NU-40		133.0	8.0%	"	135	***	99%		90%	
"	AR-NU-41		125.2	9.5%	"	135	***	93%		90%	
"	AR-NU-42		130.0	5.0%	"	135	***	96%		90%	
"	AR-NU-43		145.0	6.7%	"	135	***	107%		90%	
"	AR-NU-44		127.9	6.4%	"	135	***	95%		90%	

*** Modified Providence Tests and estimated maximum densities did not generate an optimum moisture.

(2.) Low densities are due to intermixed pockets of saturated tailings slimes. The low permeability of these slimes does not affect the performance of the compacted fill. Therefore, additional compactive effort was deemed to be non-beneficial and was not required.

(3) Tested material consisted of sandy tailings and tailings slimes. Contractor was directed to recompact this area to the approval of the Engineer. Caution was directed to prevent pumping of the slimes.

(4.) Investigation revealed the soil representative of this test was confined to a small zone and was not representative of the general area.

*Soil testing provided by ESA, Inc, Fort Collins, CO.

Table 2.6
Argentine Tailings
Field Soil Testing Summary

Date	Test No.	Location	Density	Moisture	Proctor No.	Maximum Density	Optimum Moisture	Percent Compaction	Notes	% Compaction Required	Percent +\- Moisture
19-Aug-96	AR-NU-45	3:1 Slope - Below Pond 3	111.9	11.3%	EF-05-SP-01	124	9%	90%	(5)	95%	2.3%
"	AR-NU-46		113.4	13.1%	"	124	9%	91%	(5)	95%	4.1%
"	AR-NU-47		110.5	14.3%	"	124	9%	89%	(5)	95%	5.3%
"	AR-NU-48		109.1	7.6%	"	124	9%	88%	(5)	95%	-1.4%
"	AR-NU-49		119.4	12.9%	"	124	9%	96%		95%	3.9%
"	AR-NU-50		120.9	15.8%	"	124	9%	98%		95%	6.8%
21-Aug-96	AR-NU-51	3:1 Slope - Below Pond 1	133.6	6.2%	"Estimated"	135	***	99%		90%	
"	AR-NU-52		129.0	5.9%	"	135	***	96%		90%	
"	AR-NU-53		118.8	7.8%	"	135	***	88%	(6)	90%	
"	AR-NU-54		117.9	6.9%	"	135	***	87%	(6)	90%	
"	AR-NU-55		135.9	8.4%	"	135	***	101%		90%	
"	AR-NU-56		129.2	5.5%	"	135	***	96%		90%	
"	AR-NU-57		121.0	8.5%	"	135	***	90%		90%	
24-Aug-96	AR-NU-58	Runon Ditch	118.9	12.5%	EF-10-SP-01	129	***	92%		90%	
"	AR-NU-59		113.3	10.7%	"	129	***	88%	(7)	90%	
"	AR-NU-60		115.2	14.7%	"	129	***	89%	(7)	90%	

*** Modified Providence Tests and estimated maximum densities did not generate an optimum moisture.

(5.) Contractor provided additional compaction effort in this area after nuclear gauge testing. This effort was considered sufficient and the area was accepted.

(6.) Slightly substandard results were likely due to the material being less well-graded than comparable surrounding material. However, the material was sufficiently well-graded to achieve the intent of the structural design standard based on the observed compactive effort.

(7.) Additional compaction effort was deemed to be non-beneficial in this non-critical area.

*Soil testing provided by ESA, Inc, Fort Collins, CO.

2.10.2 Confirmatory Testing

Confirmatory testing was performed at each location where specific removal of mill tailings was specified in the Voluntary Cleanup Plan (VCUP). Based on soil investigations within and surrounding the Town of Rico, Zinc levels range from 200 to 4720 ppm. The cleanup level was set at a maximum of 4720 ppm for testing of subgrade after the removal of materials. Sample results above the limit resulted in further removal and sampling. Final samples indicate the cleanup was successful. Table 2.7 summarizes the confirmatory sampling results. The comprehensive report of confirmatory testing on the Rico Project is contained in the Appendix.

Table 2.7
Argentine Tailings
Confirmatory Testing

Removal Site	Sample ID	Zinc (ppm)	Sample Type
Argentine Tailings Pond 4	EX-AR-01	1,130	Composite
	EX-AR-02	1,120	Composite

2.11 As Built Drawings

3.0 Columbia Tailings

3.1 General

The Columbia Tailings Site is located on the east side of the Dolores River corridor west of Highway 145. The east side of the pile is against the base of a steep hillside slope below Highway 145. The west side of the pile is bounded by the old railroad grade that initially served as the retention dam for the tailings pile. This inactive mill tailings disposal pile encompasses an area of approximately 3.3 acres. The Columbia Tailings surface consists of fine grained oxidized sand and silt tailings. The historic railroad grade forms a berm between the Dolores River and the steep west side of the pile.

The Columbia Tailings Site work area also includes the old Pro Patria Mill Site, the Silver Swan East waste rock pile, the Santa Cruz wetlands and the main pile excess material, and the Shamrock Mine waste rock pile. The old Pro Patria Mill Tailings Site is located on the east side of the Dolores River corridor east of the historic Rio Grande Southern Railroad grade, west of River Street and southwest of the west end of Mantz Avenue (where the historic Pro Patria Mill was located). The Pro Patria areas include approximately two acres. The Pro Patria Tailings Site was occupied with tailings and oxidized waste rock (heavy metals - predominantly iron, lead, and zinc) contained in historic mill tailings derived from sulfide ore. The Silver Swan East waste rock pile is located on the east side of the Dolores River across from the Silver Swan Mine area. The east waste rock pile occupies approximately 0.2 acres. The Shamrock Mine waste rock pile was also located on the east side of the Dolores River. The Shamrock Mine waste rock was within the Dolores River corridor about ½ mile north of the Columbia Tailings Site. The Santa Cruz is located on the west side of the Dolores River corridor south of Rico. Excess waste rock from grading activities was transported to the Columbia Tailings for ultimate disposal.

3.2 Permit

The VCRA application dated January 18, 1996 and supplemental information to the application dated February 27, 1996 and March 1, 1996 were approved by the CDPHE on March 4, 1996. The CDPHE approval stated that the VCUP would meet a degree of cleanup and control of hazardous substances such that the property does not present an unacceptable risk to human health or the environment based on the property's proposed use as an open space. The approved VCUP remedial design for the Columbia Tailings Site involves reconfiguration of tailings outslopes to control erosion, consolidation of the south area tailings, consolidation of waste rock materials from the Silver Swan East area, Pro Patria Mill area, the Shamrock Mine waste rock pile and excess waste rock from land shaping at the Santa Cruz Mine area. The Columbia Tailings is to be graded to route offsite surface water around the wastes for runon control, and surface adjustments and compaction to shed rainfall and snowmelt from the waste to control erosion and limit infiltration. The VCUP also calls for providing erosion protection through construction of reclamation covers consisting of growth medium with some amendments and seeding. Riprap was placed along the Dolores River for erosion protection. An access road, parking lot and an open air information center were also constructed on the reshaped top surface of the Columbia Tailings.

3.3 Geohazards

The hazard of concern at the Columbia Tailings Site was flooding of the Dolores River. No substantial engineering, geologic or geotechnical problems were encountered during implementation of the remedial work for the Columbia Tailings area. No slope failure problems were experienced during the materials movement and waste pile grading and contouring. Revetment was placed along the north toe of the reshaped tailings and also on the railroad grade berm susceptible to erosion from the Dolores River flooding. Areas of riprap placement are shown on Figure 3-1.

3.4 Site Access

Access to the Columbia Tailings, Pro Patria Tailings, Silver Swan East and Shamrock waste rock Sites was available on existing roads. Direct access between the Sites is along the historic railroad grade, dirt roads and some paved roads in west Rico. Properties encompassing the railroad grade are owned by the private party applicant, Rico Properties, L.L.C. All roads were maintained and left in as good or better condition than existed prior to their use on this project. Waste hauled from the Santa Cruz Mine area to Columbia used access over a USFS bridge and this access was maintained in compliance with the USFS Road Use Permit. A Colorado Department of Transportation State Highway Access Permit was obtained for the access to the Columbia Tailings Visitors Center from State Highway 145.

3.5 Construction Site Controls

Controls were implemented during construction to address requirements of applicable federal, state or local permits, codes or regulations. All construction and specifications employed appropriate Best Management Practices in accordance with the Stormwater Discharge Permit and COE 404 Permit to protect the Dolores River from sedimentation during remedial activities. Temporary berms to control runoff to the Dolores River were constructed in work or active traffic areas. Silt fencing and hay bales were used as barriers to prevent sediment migration into the Dolores River during excavation activities. Also, construction activities were conducted in a manner to preserve existing vegetation buffers in the work areas. Runoff water from disturbed areas was retained for settling of sediments prior to allowing discharge into Dolores River. Strict precautions to avoid dust and excavation spillage during operations were followed by the use of water spray and control of load heaping on haul units.

The onsite construction activities were conducted in strict compliance with the VCUP Site Specific Safety and Health Plan and Site Pre-Excavation Construction Plans as well as regulatory permits obtained for the specific work area.

3.6 Hydraulic Controls

3.6.1 Runon

The runon generated from rainfall or snowmelt upland of the Site is directed away from the Columbia reclaimed tailings ponds by a 600 linear foot riprap lined runon ditch. The runon/runoff ditch was excavated into the natural ground surface at the toe of the east reconfigured slope of the Site. Stormwater is directed south and west in the runon/runoff ditch and spills into a retention area south of the Columbia Tailings. The retention area was created by the removal of tailings in between the main tailings area and the railroad grade. Figure 3-1 shows the alignment of the runon/runoff ditch. The main portion of the ditch consists of a riprap lined channel over 60 mil HDPE textured liner. Type B riprap 6 inches thick was laid over 6 inches of Type D and 6 inches of compacted soil material in a trapezoidal designed ditch up to the access road. The runon/runoff ditch stormwater is passed under the access road from State Highway 145 in a 24 inch RCP. The 24 inch RCP was 142 ft. in length and was installed with a riprap inlet and outlet. The remaining runon/runoff ditch from the access road to the retention area is about a 12-inch deep trapezoidal channel approximately 2.0 feet wide at the base. The channel was lined with Type B riprap 6 inches thick over 6 inches of Type D bedding and 6 inches of compacted soil material.

3.6.2 Runoff

The top surface of the consolidated waste pile has been shaped to drain precipitation and not retain runoff on the pile. The graded pile drains stormwater to the west. The top surface and areas within the access roads on the top surface are graded at about 2% to the west. Runoff is passed across the west road in a concrete lined swale (pan) and drains from the pile to the north west.

The runoff from the eastern graded outslope is captured by the runon/runoff ditch and drained to the south of the pile. The design of the runon/runoff ditch is discussed in Section 3.6.1. Stormwater is drained into a retention area south of the Columbia Tailings. This flow will eventually reach the Dolores River through a 24-inch RCP across the existing railroad grade. This drain consists of Type B riprap placed 15 ft. deep by 3 ft. and is 2 ft. deep. Figure 3-1 shows the location of the retention area and the RCP pipe.

Outslopes of the reconfigured tailings are 4h:1v and runoff water is drained away from the pile. The north slope of the Columbia drains into the existing wetlands. The west slope drains into the Dolores River and the east and south slopes into the retention area and then into the Dolores by way of the RCP pipe.

The runon and runoff ditches are sized to pass peak flows for a 100 year precipitation event. Figure 3-1 shows the runoff ditch location.

3.6.3 Infiltration

Infiltration of water into the tailings ponds at the Columbia Site is controlled by rerouting runon away from the reclaimed areas, reducing the surface area of the tailings, regrading of the tailings to not pond water and compaction of the top surface of the reclaimed tailings to impede infiltration.

The rerouting of the runon and runoff away from the tailings will be of significant impact for reducing infiltration. The runon water contribution to the tailings areas has been eliminated.

The area south of the Columbia Tailings was removed and placed onto the main portion of the tailings. The surface area of the tailings pile has been reduced by 15% and therefore reducing the infiltration surface available. The total area of the tailings was reduced by 0.4 acres which left a total of 2.7 acres of surface. The tailings were consolidated by excavation of the tailings material from the south area between the railroad grade and the natural ground to the east, then hauled and placed as compacted cover over the surface of the main tailings area.

The upper 18 inches of top surface and outslopes of the Columbia Tailings pile were compacted to impede infiltration. With the material types encountered in the tailings, the density that is achieved by this compaction will reduce the hydraulic conductivity. The results of compaction testing conducted on the Columbia Tailings reconfigured surface are summarized in Section 3.10.

3.6.4 Drainage Stabilization

The Columbia Tailings Ponds are adjacent to the Dolores River and may be susceptible to seasonal flooding. The Columbia Tailings are protected by the existing railroad fill between the Site and the Dolores River. This railroad fill serves as a protective dike and adequately contains the flood flow of the Dolores River for the estimated 500 year flood event with a 2 ft. freeboard. Riprap revetment was placed on the railroad fill bank slope to protect the fill from peak flow velocities experienced during flooding. The north slope of the Columbia Tailings is also protected from high river flood velocities by the riprap revetment. Riprap construction is discussed in Section 3.8 of this report.

3.7 Waste Materials

3.7.1 Consolidation

Waste materials from several areas along the Dolores River corridor in the vicinity of the Columbia were excavated and consolidated at the Columbia Tailings Site. Tailings existing at the Pro Patria and some mixed waste rock, approximately 7,300 cubic yards, were removed from the Pro Patria Mill area and hauled to the Columbia Tailings. About 600 cubic yards of waste rock from the dump on the east bank of the Dolores River at the Silver Swan Mine area was excavated, hauled and deposited at the Columbia Tailings pile.

Additionally, 5,200 cubic yards of waste rock from the Santa Cruz Mine cleanup activities that did not fit into the grading plan were relocated to the

Columbia Tailings. Approximately 1,270 cubic yards of waste rock from the Shamrock Mine located north of the Pro Patria Site on the east bank of the Dolores River was removed to the Columbia Tailings pile. Shallow tailings totaling 1,500 cubic yards located at the south end of the main Columbia Tailings were excavated and relocated to the main pile. The consolidation of these wastes to the Columbia Tailings reduced the net area of the sites by over 2 acres. The locations of the areas excavated are shown on Figures 3-1, 4-1 and 5-1.

Tailings were removed in layers of about 12 inches in thickness by conventional earthmoving equipment. Following removal, confirmatory sampling was conducted to detect if all waste material had been removed. This process was repeated until confirmation sampling showed that no additional material removal was required.

Verification of tailings removal was accomplished by collecting confirmatory samples of the underlying materials. Waste rock and tailings excavation was considered completed, as defined in the VCUP, when the Zinc content fell within or below the range of local natural bedrock and surficial materials. This range is 200 to 4720 ppm Zinc. The sampling of the removal areas confirms that the majority of tailings was excavated from the areas of concern. Sampling results and summaries for the removal of the respective areas are contained in Section 3.10.2.

The relocated tailings were placed onto the top of the main Columbia Tailings pile in lifts not exceeding 12-inches in depth and were compacted. The compaction effort was accomplished by placement equipment making a minimum of one pass over the entire surface of each 12-inch lift. Tailings placed in the upper 18-inches of the top surface were compacted as previously described.

3.7.2 Surface Shaping and Slopes

The top surface of the consolidated tailings drains to the west at 2%. The tailings have been reconfigured with all of the outslopes draining the Site. The outslopes of the reconfigured Columbia Tailings are constructed to a 4h:1v geometry. The reconfigurement of the Columbia Tailings was accomplished by a cut and fill approach with a major portion of the slope fill being from consolidation of other waste areas. The grading was completed to a tolerance of $\pm$ 0.3 ft. of construction drawings and free of irregularities.

Figure 3-1 shows the pre-existing conditions, VCUP design configuration and the as built conditions of the Columbia Tailings.

3.8 Erosion Protection

3.8.1 Growth Medium

Growth medium material comprises compacted surface tailings and soil cover. The top surface of the reshaped Argentine Tailings was sampled to determine agricultural lime ($CaCO_3$) requirements for plant establishment. Areas requiring lime amendment were delineated in the field. Lime was applied at rates of 125 to 500 tons/acre to the upper 6-inches of waste material. Table 3.1 shows the lime application rates for the Columbia Tailings. Agricultural lime was also added to the tailings existing on the hillside slopes at the Pro Patria Tailings Area and is described on Table 3.1. The lime was spread evenly over the Site by mechanical methods then incorporated. Multiple tilling passes were made to insure complete mixing of the lime into the material. The liming process was accomplished immediately following waste pile shaping to provide the greatest reaction time prior to revegetation. Amended material was re-compacted prior to placement of soil cover material.

Borrow soil used for plant growth was tested and identified prior to excavation. The borrow soil was obtained from the St. Louis borrow area 1.5 miles north of the Columbia Tailings, the Pro Patria Tailings and the Shamrock Mine Area. The soil was transported by truck to the Columbia Tailings and placed over the top of the lime amended material to a depth of 24-inches. Table 3.1 describes the placement of the soil material at the Columbia Tailings, Pro Patria Area and the Shamrock Mine Area. This soil was placed on the top surface and slopes and covered the entire areal extent of the regraded waste pile. Approximately 9,000 cubic yards of soil cover material were transported and placed onto the Columbia. The traffic over the soil was kept to a minimum to avoid unnecessary compaction of the seed bed. The finished grade for the soil cover is $\pm$ 0.3 ft. of design and does not contain irregularities.

Table 3.1
Columbia Tailings, Pro Patria Tailings Area, Shamrock Mine Area
Agricultural Lime and Cover Material Application Rates

SITE	LIME APPLICATION RATE FOR WASTE MATERIAL	SOIL COVER APPLICATION RATE
North and West 4:1 slopes	500 tons/acre (2.9 in. thick) Amended 6 inches deep and compacted	18-inches of unprocessed borrow soil covered by 6 inches of growth processed borrow soil.
East 4:1 slope	225 tons/acre (1.3 in. thick) Amended 6 inches deep and compacted	
Tailings on east side of runon/runoff ditch	225 tons/acre (1.3 in. thick) Amended 6 inches deep and compacted	
Small area on south top of pile	500 tons/acre (2.9 in. thick) Amended 6 inches deep and compacted	
Top of Columbia pile	125 tons/acre (0.7 in. thick) Amended 6 inches deep and compacted	
Pro Patria Tailings Area	200 tons/acre (1.0 in. thick) Amended 6 inches deep and compacted (hillside slopes)	12-inches of processed borrow soil
Shamrock Mine Area	No lime application required	6 to 12 inches of processed borrow soil

3.8.2 Revegetation

All seed was applied using hydroseeding methods due to wet surface conditions and time constraints. Table 3.2 contains the seed mixtures and application rates at the Columbia Tailings. Seeding of the Pro Patria Tailings Area included Type D in the wetlands area and Type B in the slopes. The Shamrock Mine Area was hydroseeded with the Type D mixture. Revegetation activities were sequenced as shown on Table 3.3.

Table 3.2
Seed Mixtures and Application Rates

Type A (1)
General Seed Mixture

Species	Preferred Variety(s)	Rate (lbs./acre) Planted (broadcast)	PLS (seeded/acre)
Big bluegrass Poa ampla	Sherman	0.50	458,500
Mountain brome Bromus carinatus	Bromar	8.00	496,000
Slender wheatgrass Agropyron trachycaulum	Primar, San Luis	3.00	480,000
Streambank wheatgrass Agropyron riparium	Sodar	3.00	480,000
Birdsfoot trefoil Lotus corniculatus	Empire	1.00	410,000
Lewis flax Linum lewisii	Apar	2.00	570,000
Rocky Mountain penstemon Penstemon strictus	Bandera	1.00	592,000
Cicer milkvetch Astragalus cicer	Lutana, Monarch	1.50	290,000
	Totals	**20.00**	**3,776,500 (approx. 87 seeds per square foot)**

(1) Type A applied over entire area of disturbances, except for the railroad grade, access road loop and areas protected by riprap.

Type B (2) Sideslope Stabilization Mixture			
Species	**Preferred Variety(s)**	**Rate (lbs./acre) Planted (broadcast)**	**PLS (seeded/acre)**
Big bluegrass Poa ampla	Park	0.50	1,100,000
Mountain brome Bromus carinatus	Bromar	15.00	975,000
Slender wheatgrass Agropyron trachycaulum	Primar, San Luis	6.00	960,000
Streambank wheatgrass Agropyron riparium	Sodar	6.00	960,000
Cicer milkvetch Astragalus cicer	Lutana, Monarch	1.50	290,000
	Totals	**29.00**	**4,285,000 (approx. 98 seeds per square foot)**

Type D (3) (Wetland Planting Mixture)			
Species	**Preferred Variety(s)**	**Rate (lbs./acre) Planted (broadcast)**	**PLS (seeded/acre)**
Redtop (FACW) Agrostis alba	Any	0.50	2,495,000
Red fescue (FAC) Festuca rubra	Any	3.00	1,845,000
Tall (Kentucky) fescue (FACW-) Festuca arundinaceae	Any	5.00	1,135,000
	Totals	**8.25**	**5,475,000 (approx. 126 seeds per square foot)**

(2) Type B applied on east slope of railroad grade between the Columbia Tailings and the RCP at the south end of the Site.
(3) Wetlands Type B planting mixture used at Pro Patria and Shamrock areas.

Table 3.3
Columbia Tailings, Pro Patria Tailings Area, Shamrock Mine Area Revegetation Sequence

Item	*Seed Bed Preparation*	*Fertilizer*	*Seed*	*Mulch*
Period	Prior to fertilization and seeding.	Concurrent with seeding.	After September 30th, immediately following final seed bed preparation.	Immediately following seeding.
Method	Mechanical scarification of soil.	Combined with hydroseeding. Liquid fertilizer mixture.	Hydroseeding on all areas.	Hydromulch - 1500 lbs./acre, all areas. Slurry pH> 3.5.
Equipment	Disc or rippers pulled by tractor.	Mobile hydroseeding equipment.	Mobile hydroseeding with spray and tank equipment.	
Discing/Raking	Disc or rip to 12 inch depth maximum.			
Other	Insure adequate seed bed without hard surface resistant to seed placement.	Nutrient application applies to all sites: Nitrogen (lb./acre): 40 Phosphate (lb./acre): 60 Potash (lb./acre): 40	Seed depth = 1/4" to 1/2" Spacing = 6" Type A General seed mix (<3:1) B Side slope mix (>3:1) C Acid-tolerant mix	Purpose: twofold: 1. Conserve water 2. Deter erosion

Note: Ripping of final graded surface completed as needed prior to applying fertilizer.

3.8.3 Riprap

Rock erosion protection was placed in areas where runoff, runon and drainage way flows were considered to be highly erosive. Riprap and bedding types are shown on Table 3.4.

Table 3.4
Columbia Tailings
Riprap and Bedding

		Percent Passing					
Type	**Description**	**100**	**85**	**50**	**30**	**15**	**0**
A	Riprap	1.7-2.4'	-	1.4'-1.6'	1.2'	0.9'	0.8'
B	Riprap	Larger Rock Material Generated By Borrow Processing					
C	Riprap	0.9-1.2'	-	0.7-0.8'	0.6'	0.5-0.65'	0.4
D	Riprap/Bedding	3.0-8.0"	3.0-6.0"	-	-	0.75"-1.5"	0"-0.5"
E	Filter Material/Bedding	2.0"	0.5-1.5"	-	-	0.5-0.65mm	0.6mm

The runon and runoff ditch alignments are shown in the plan view on Figure 3-1. These ditches contain riprap, bedding and HDPE textured liner to handle flows resulting from a 100 year precipitation return event. These designs are discussed in detail under Section 3.3.

The railroad fill embankment and the north 4h:1v slope of the Columbia Tailings were protected from erosive flood flow by placement of revetment. The revetment placed along the Dolores River over the historical railroad fill consists of a scour toe of Type A riprap placed about 3.6 ft. thick below the water level. Type A riprap was placed over the existing scour toe and up the existing slope. The Type A riprap was constructed over 6 inches of Type D bedding and 6 inches of Type E bedding, respectively, existing at or below the water surface where fill was placed with Type D material. The riprap placed above the average water line is Type A. This revetment was constructed to provide a 2 ft. freeboard above the 500 year flood level of the Dolores River.

Revetment placed on the northwest corner of the railroad fill is built of a 2.4 ft. layer of Type A riprap over Type D and Type E bedding. Flood protection revetment on the north slope of the reconfigured Columbia Tailings slope is also a 1.2. ft. layer of Type C riprap over 6 inches of Type D and 6 inches of Type E bedding. The existing ground in the wetland area north of the Columbia Tailings was pushed up to and over the lower portion of the revetment on the north slope.

3.9 Quantity Summary

The quantities moved for implementation of the VCUP for the Columbia Tailings involved ten categories of materials. The total volume of materials moved was 28,247 cubic yards. Table 3.5 contains the volume of moved materials by category for earthwork at the Columbia Tailings.

Table 3.5
Columbia Tailings
Relocated Materials, Riprap and Bedding

Activity	Material Type	Units	Quantities
Relocated Waste Rock	***	CY	14,650
Unprocessed Cover Soil	Borrow Soil	CY	1,968
Processed Cover Soil	-3/4" Borrow Soil	CY	8,945
Riprap	A	CY	1,171
Riprap	B	CY	119
Riprap	C	CY	429
Riprap Bedding	D	CY	542
Riprap Bedding	E	CY	423
Textured Liner	HDPE	$Yd.^2$	1,073
Road Subgrade Reinforcement	Geogrid	$Yd.^2$	
Soil Amendment	Agricultural Lime	Tons	166

3.10 Soil Testing Summary

3.10 Soil Testing Summary

3.10.1 Geotechnical Testing

Field soil density testing was conducted to determine compliance with the technical specifications of the construction contract. The technical specifications relating to compaction were selected to achieve various engineering objectives relating to infiltration and enhancing stability in fill materials. The applicable technical specifications required that the upper 12 inches of the waste piles be of a compactable gradation, and attain 95% of Standard Proctor maximum dry density (or 90% of maximum Providence index density for soils with little or no fines). Table 3.6 summarizes the field soil moisture/density tests conducted for the Argentine Tailings. Nuclear density gauges were used to obtain in-place densities for comparison to laboratory generated Proctor or Providence mold laboratory density tests as appropriate for a given soil. Where moisture/density tests were deficient, footnotes in Table 3.6 indicates the action taken by the field engineer, e.g. - recompaction of the affected area or in cases where additional compaction or replacement of fill materials would not have provided any additional benefits to the long-term performance of the fill with respect to design objectives, no action was directed. Laboratory and field tests were performed and results approved by ARCO. Tests were conducted according to the following standards:

ASTM Method	Description:
Field Tests:	
D-2922	Density of Soil and Soil-Aggregate in Place by Nuclear Methods
Laboratory Tests:	
D-422	Sieve Analysis
D-698	Moisture Density Relationships (5.5 lb. hammer)
D-4253	Modified Providence Moisture Density Relationships

Table 3.6 summarizes the results of field tests.

Table 3.6
Columbia Tailings
Field Soil Testing Summary

Date	Test No.	Location	Density	Moisture	Proctor No.	Maximum Density	Optimum Moisture	Percent Compaction	Notes	% Compaction Required	Percent +\- Moisture
14-Aug-96	CO-NU-01	Runon/Runoff Ditch and RCP Compacted Bedding	125.5	17.8%	EF-03-MP-01	130	***	97%		90%	
"	CO-NU-02		118.7	19.4%	"	130	***	91%		90%	
"	CO-NU-03		101.5	18.1%	"	130	***	78%	(1)	90%	
"	CO-NU-04		125.9	16.7%	"	130	***	97%		90%	
21-Aug-96	CO-NU-05	4:1 slopes north and west, Pre Amendment	125.1	9.5%	EF-03-MP-01	130	***	96%		90%	
"	CO-NU-06		118.3	11.5%	EF-08-MP-01	120	***	99%		90%	
"	CO-NU-07		105.2	11.3%	EF-08-MP-01	120	***	88%	(2)	90%	
"	CO-NU-08		105.2	14.6%	EF-08-MP-01	120	***	88%	(2)	90%	
"	CO-NU-09		112.0	11.7%	EF-03-MP-01	130	***	86%	(2)	90%	
"	CO-NU-10		125.8	12.6%	EF-03-MP-01	130	***	97%		90%	
"	CO-NU-11		102.4	16.2%	EF-08-MP-01	120	***	85%	(2)	90%	
"	CO-NU-12		116.9	11.8%	EF-03-MP-01	130	***	90%		90%	
"	CO-NU-13		104.7	11.0%	EF-03-MP-01	130	***	81%	(2)	90%	

*** Modified Providence Tests and estimated maximum densities did not generate an optimum moisture.

(1.) Investigation revealed the soil representative of this test was confined to a small zone and was not representative of the general area. Additional compactive effort was deemed non-beneficial and was not required.

(2.) Tested material consisted of tailings slimes. The relative impermeability due to the fine-grained nature of this material meets the infiltration performance standards. Therefore, additional compaction effort of the slightly substandard results was deemed to be non-beneficial and was not required.

* Soil testing provided by ESA, Inc., Fort Collins, CO.

Table 3.6
Columbia Tailings
Field Soil Testing Summary

Date	Test No.	Location	Density	Moisture	Proctor No.	Maximum Density	Optimum Moisture	Percent Compaction	Notes	% Compaction Required	Percent +\- Moisture
3-Sep-96	CO-NU-14	Top of Pile, Pre-Amendment	120.0	17.4%	EF-03-MP-01	130	***	92%		90%	
"	CO-NU-15		124.5	16.5%	"	130	***	96%		90%	
"	CO-NU-16		117.1	13.3%	"	130	***	90%		90%	
"	CO-NU-17		118.2	15.6%	"	130	***	91%		90%	
"	CO-NU-18		120.7	18.7%	"	130	***	93%		90%	
"	CO-NU-19		119.1	18.4%	"	130	***	92%		90%	
"	CO-NU-20		126.9	13.9%	"	130	***	98%		90%	
"	CO-NU-21		122.6	15.0%	"	130	***	94%		90%	
"	CO-NU-22		122.4	13.0%	"	130	***	94%		90%	
"	CO-NU-23		144.4	12.9%	"	130	***	111%		90%	
5-Sep-96	CO-NU-24	Top of Pile, Post-Amendment	121.9	11.9%	Estimate	132	***	92%		90%	
"	CO-NU-25		126.0	11.1%	"	132	***	95%		90%	
"	CO-NU-26		120.6	10.9%	"	132	***	91%		90%	
"	CO-NU-27		129.3	8.8%	"	132	***	98%		90%	
"	CO-NU-28		125.4	11.6%	"	132	***	95%		90%	
"	CO-NU-29		123.2	11.1%	"	132	***	93%		90%	
"	CO-NU-30		122.3	9.9%	"	132	***	93%		90%	
5-Sep-96	CO-NU-31	Runon/Runoff Ditch & Liner Bedding	106.9	12.8%	EF-10-SP-01	129	12%	83%	(3)	90%	0.8%
"	CO-NU-32		99.0	13.0%	"	129	12%	77%	(3)	90%	1.0%
"	CO-NU-33		97.1	12.3%	"	129	12%	75%	(3)	90%	0.3%
"	CO-NU-34		104.3	12.4%	"	129	12%	81%	(3)	90%	0.4%

*** Modified Providence Tests and estimated maximum densities did not generate an optimum moisture.

(3.) Additional compaction effort was undertaken by the contractor.

* Soil testing provided by ESA, Inc., Fort Collins, CO.

Table 3.6
Columbia Tailings
Field Soil Testing Summary

Date	Test No.	Location	Density	Moisture	Proctor No.	Maximum Density	Optimum Moisture	Percent Compaction	Notes	% Compaction Required	Percent +\- Moisture
11-Sep-96	CO-NU-35	4:1 Slopes	122.4	6.9%	Estimate	135	***	91%		90%	
"	CO-NU-36	Post Amendment	112.2	16.3%	EF-03-MP-01	130	***	86%	(4)	90%	
"	CO-NU-37		120.4	15.5%	"	130	***	93%		90%	
"	CO-NU-38		124.4	12.7%	"	130	***	96%		90%	
"	CO-NU-39		119.6	10.5%	Estimate	135	***	89%	(4)	90%	
"	CO-NU-40		114.8	13.3%	"	135	***	85%	(4)	90%	
"	CO-NU-41		123.8	9.9%	EF-03-MP-01	130	***	95%		90%	
"	CO-NU-42		108.5	8.3%	"	130	***	83%	(4)	90%	
"	CO-NU-43		121.0	8.1%	"	130	***	93%		90%	
"	CO-NU-44		129.5	11.8%	"	130	***	100%		90%	
1-Oct-96	CO-NU-45	Subgrade for	116.1	14.1%	EF-10-SP-01	129	12%	90%		90%	2.1%
"	CO-NU-46	Visitor's Center	112.4	14.7%	"	129	12%	87%	(5)	90%	2.7%
"	CO-NU-47	Concrete Slab	109.4	14.0%	"	129	12%	85%	(5)	90%	2.0%
"	CO-NU-48	"	109.8	13.7%	"	129	12%	85%	(5)	90%	1.7%
"	CO-NU-49		118.5	14.9%	"	129	12%	92%		90%	2.9%
"	CO-NU-46R	Retests after	122.1	15.3%	EF-10-SP-01	129	12%	95%		90%	3.3%
"	CO-NU-47R	reworking subgrade	122.1	14.9%	"	129	12%	95%		90%	2.9%
"	CO-NU-48R	"	123.0	15.1%	"	129	12%	95%		90%	3.1%

*** Modified Providence Tests and estimated maximum densities did not generate an optimum moisture.

Note: Since Columbia Access Road was not part of the remediation earth work, the field density tests are not presented here.

(4.) Contractor provided additional compaction effort in this area after nuclear gauge testing. The additional effort was considered sufficient.

(5.) Additional compaction effort was directed. Results of retests met design standards and the area was accepted.

* Soil testing provided by ESA, Inc., Fort Collins, CO.

3.10.2 Confirmatory Testing

we need this data

What about lead?

Confirmatory testing was performed at each location where specific removal of mine waste rock or mill tailings was specified in the VCUP. Based on soil investigations within and surrounding the Town of Rico, Zinc levels range from 200 to 4720 ppm. The cleanup level was set at a maximum of 4720 ppm for testing of subgrade after the removal of materials. Sample results above the limit resulted in further removal and sampling. Final samples indicate the cleanup was successful. Table 3.7 summarizes the confirmatory sampling results. The comprehensive report of confirmatory testing on the Rico Project is contained in the Appendix.

Table 3.7
Columbia Tailings, Silver Swan East, Pro Patria, Shamrock, Santa Cruz Confirmatory Testing

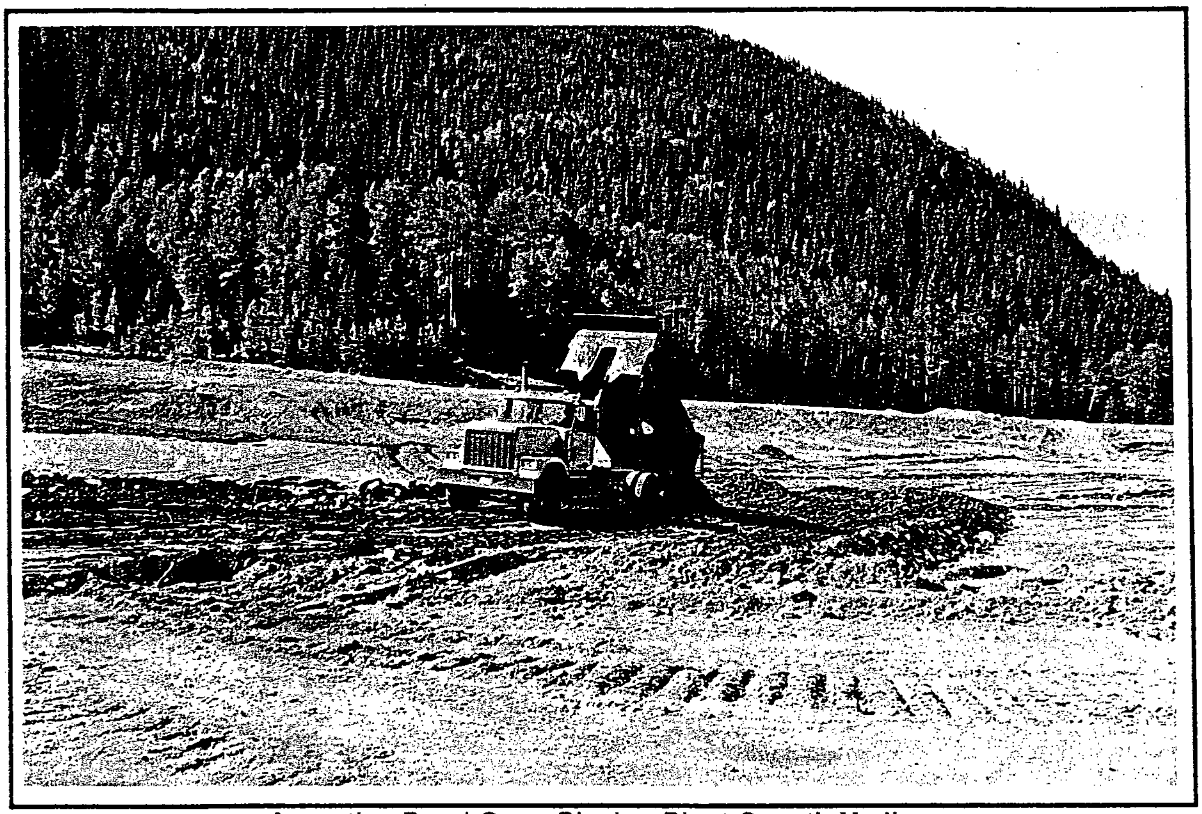
Removal Site	Sample ID	Zinc (ppm)	Sample Type
Columbia Tailings south	EX-CO-01	651	Composite
Pro Patria	EX-PP-02	3,840	Composite
Santa Cruz	EX-SC-02	1,440	Composite
	EX-SC-03	2,640	Single sample
	EX-SC-04	422	Single sample
Shamrock east bank	EX-SH-01	3,740	Composite
Silver Swan east bank	EX-SSE-01	2,030	Composite

3.11 Visitor Center

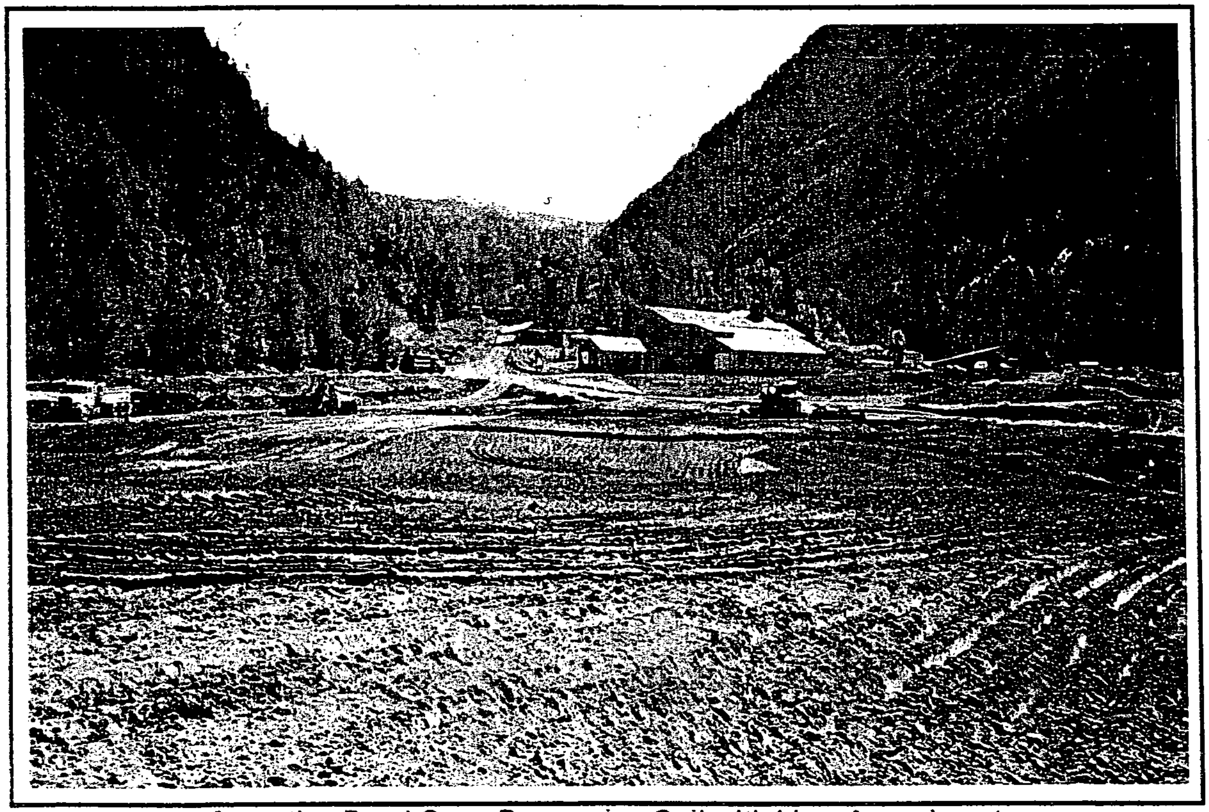
As shown on Figure 3-1, visitor center was constructed over the completed surface of the Columbia Tailings to comply with land use described in the approved VCRA application. The visitor center consists of a loop access road from Colorado State Highway 145, a parking area and an information pavilion. The open air center is constructed of decorative concrete support columns with a metal type standing seam roof. The access road and parking area were surfaced with of clean gravel. Some Columbia waste materials are subject to soft ground conditions. To improve the effective bearing capacity of the loop road and parking areas, the constructed subgrade comprises 12 inches of structural fill reinforced with geogrid.

3.12 As Built Drawings

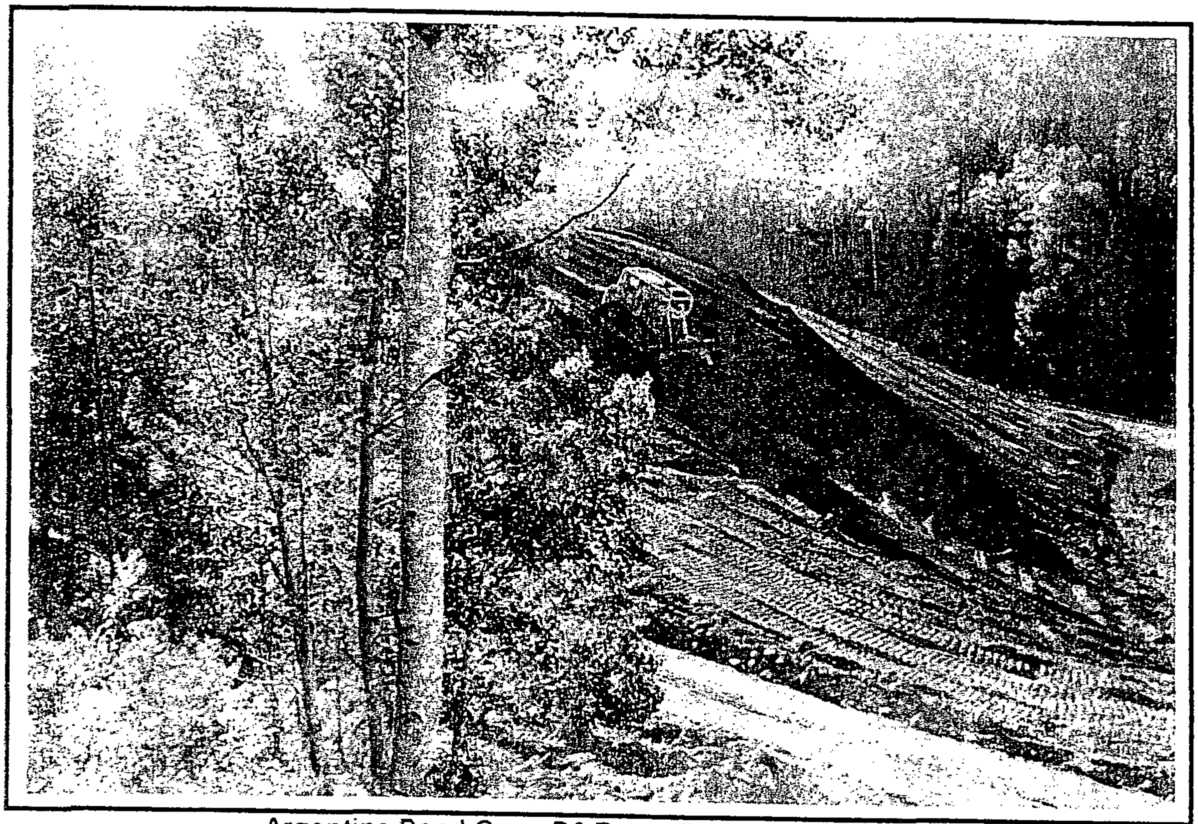
Drainage Line Construction - Offset for Energy Dissipation Structure



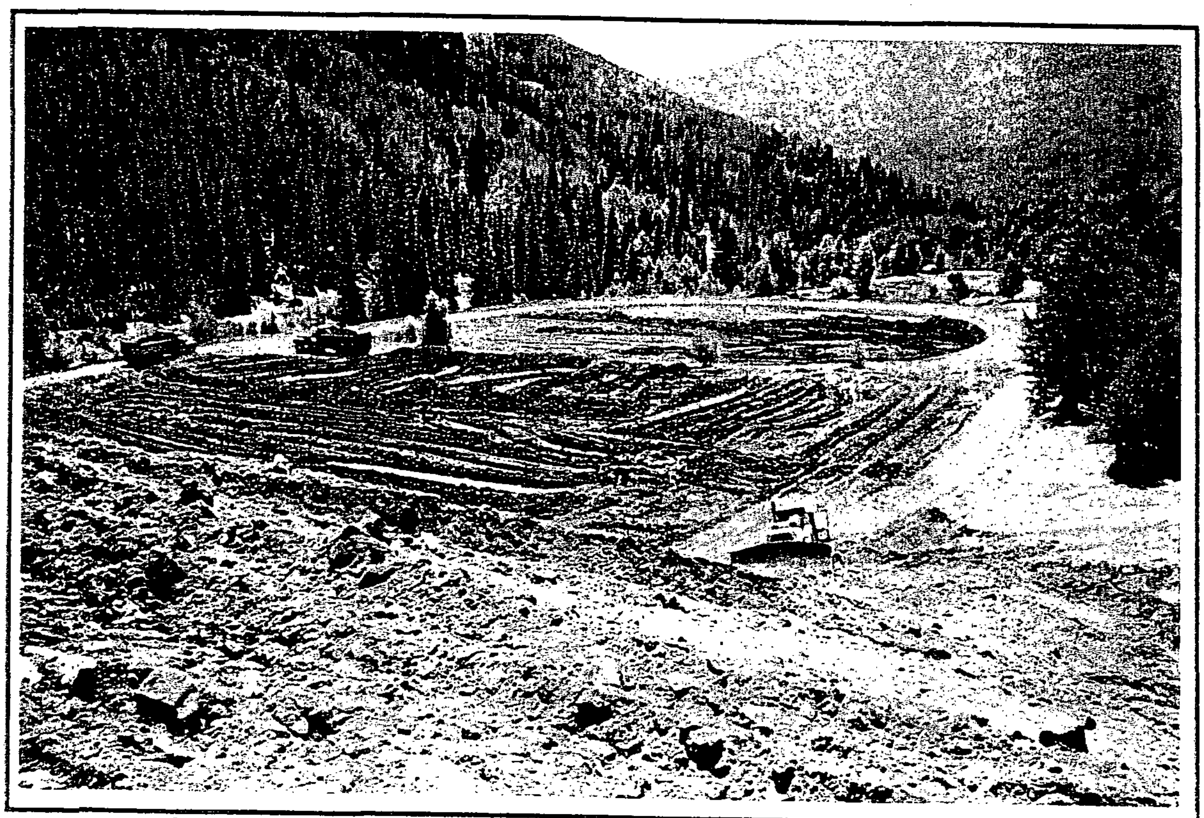
Argentine Pond One - Placing Plant Growth Medium



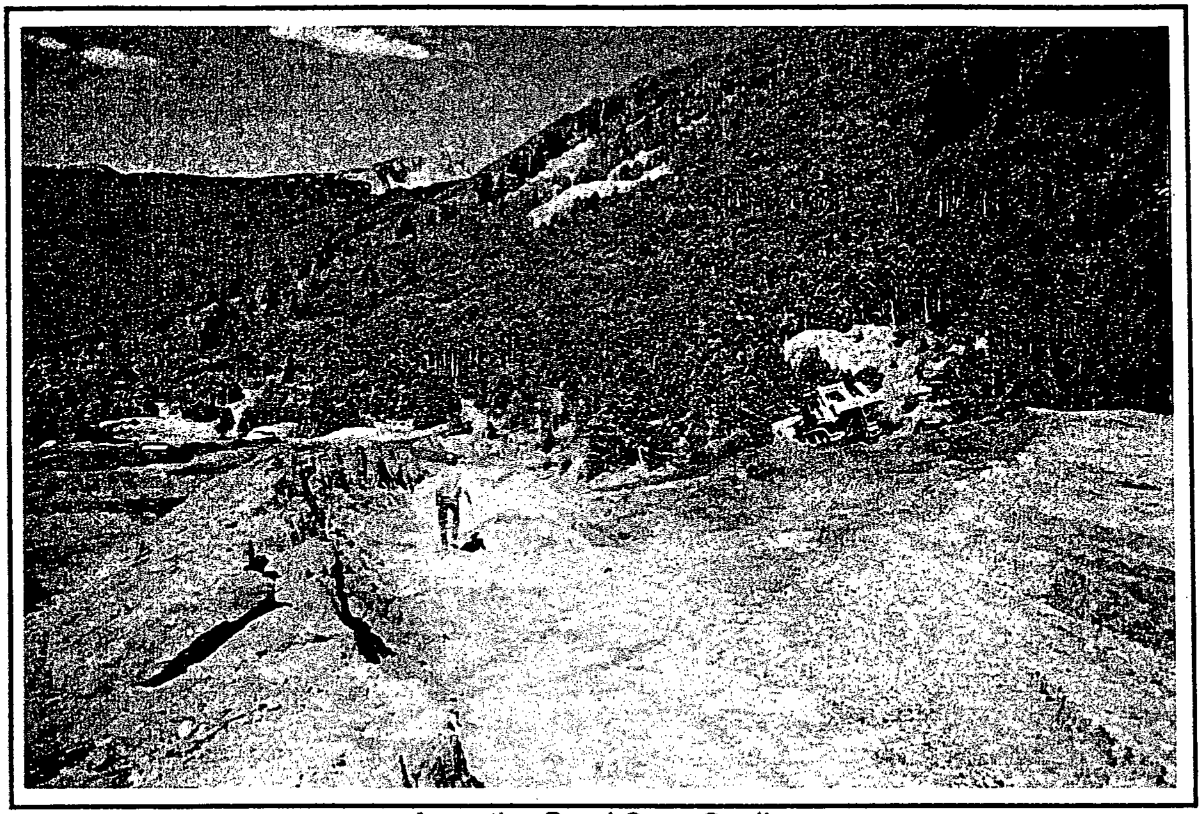
Argentine Pond One - Processing Soil with Lime Amendment



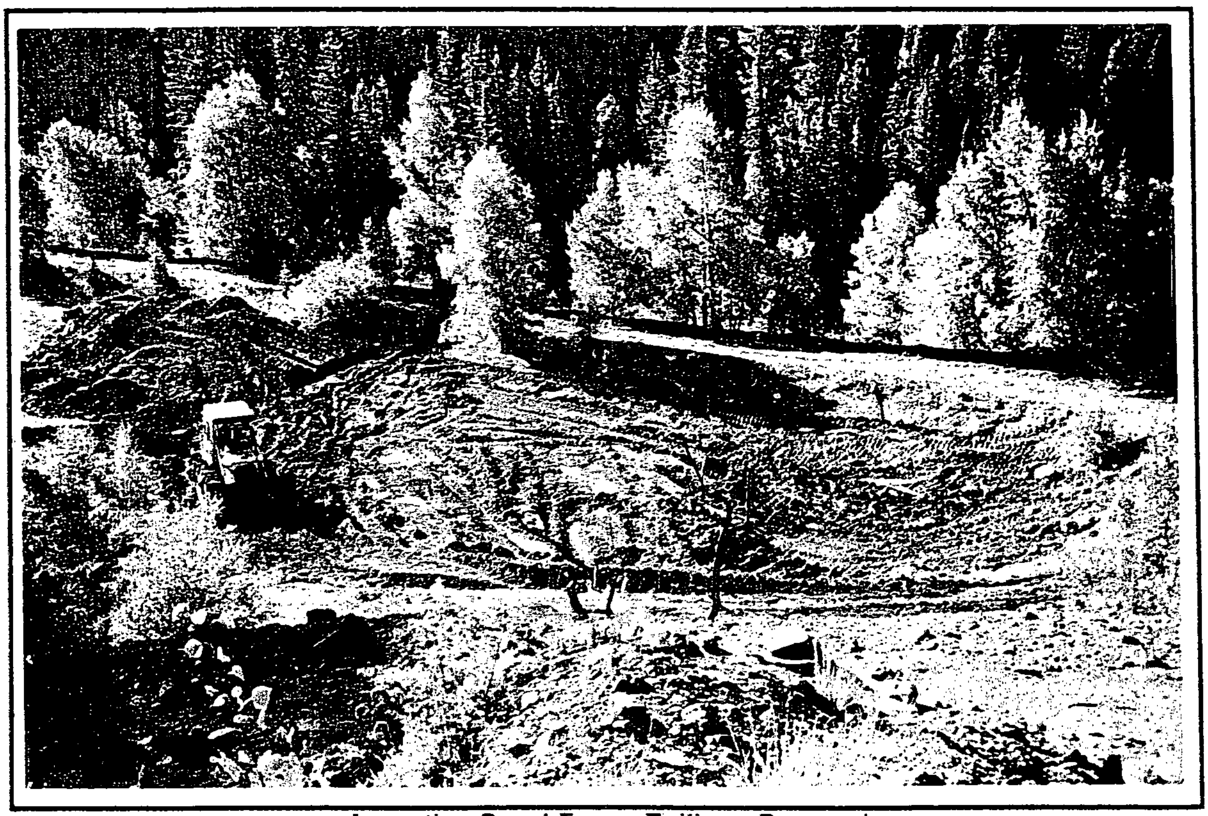
Argentine Pond One - D6 Reconfiguring 3h:1v Slope



Argentine Ponds Two and Three - Placement of Pond Four Tailings



Argentine Pond One - Grading

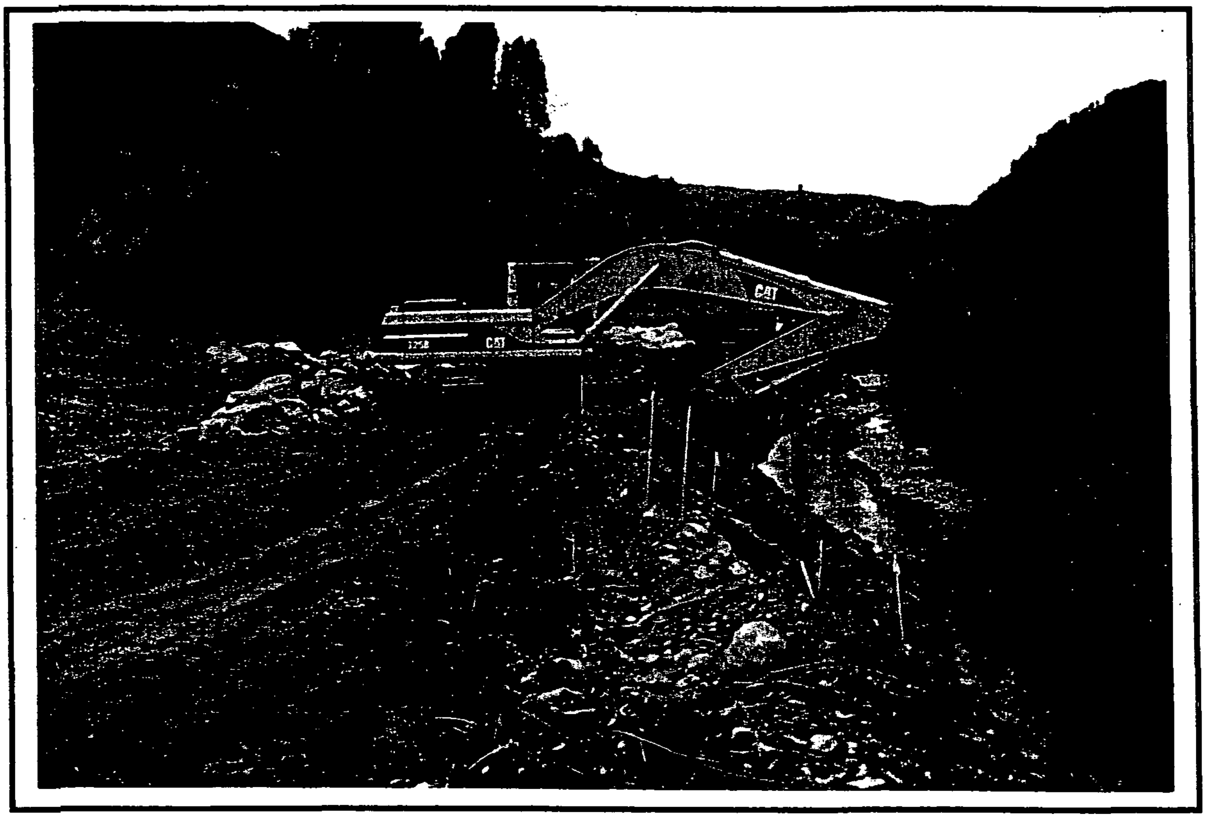


Argentine Pond Four - Tailings Removal

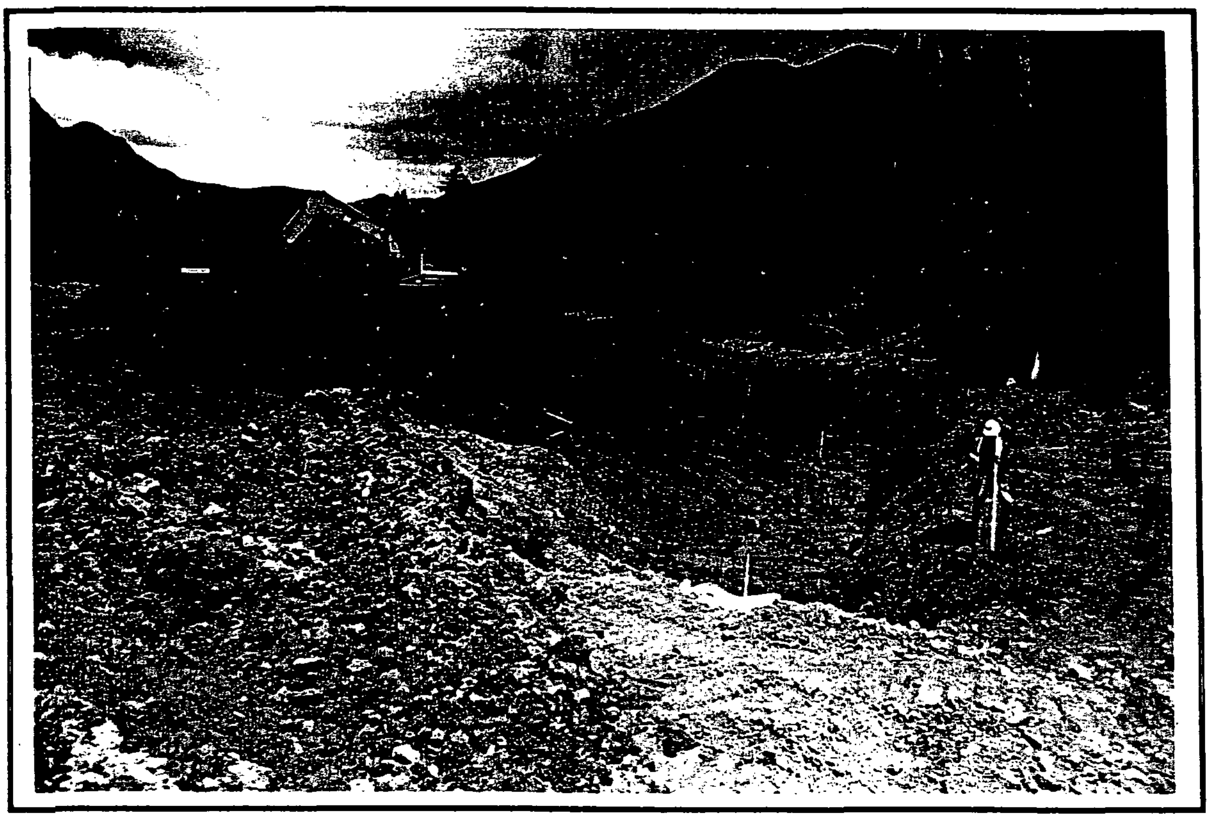
2.12 Photographs

4.12 As Built Drawings

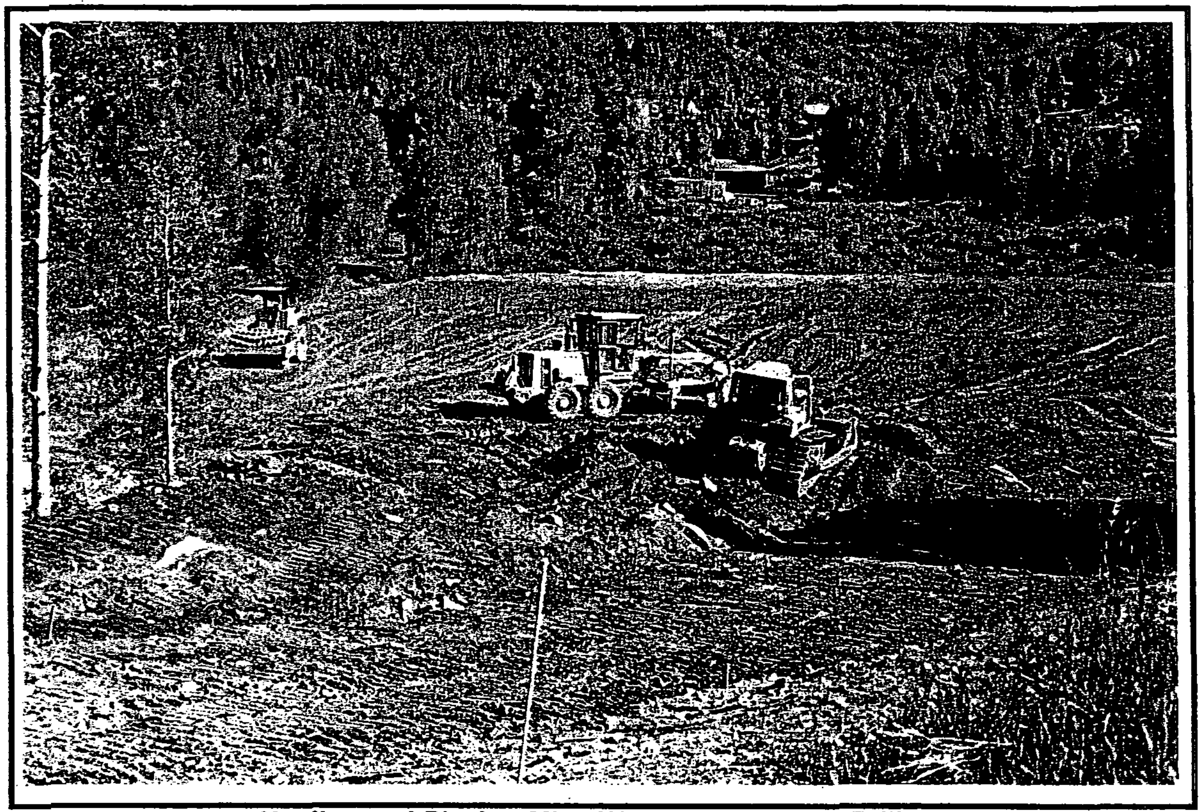
3.13 Photographs



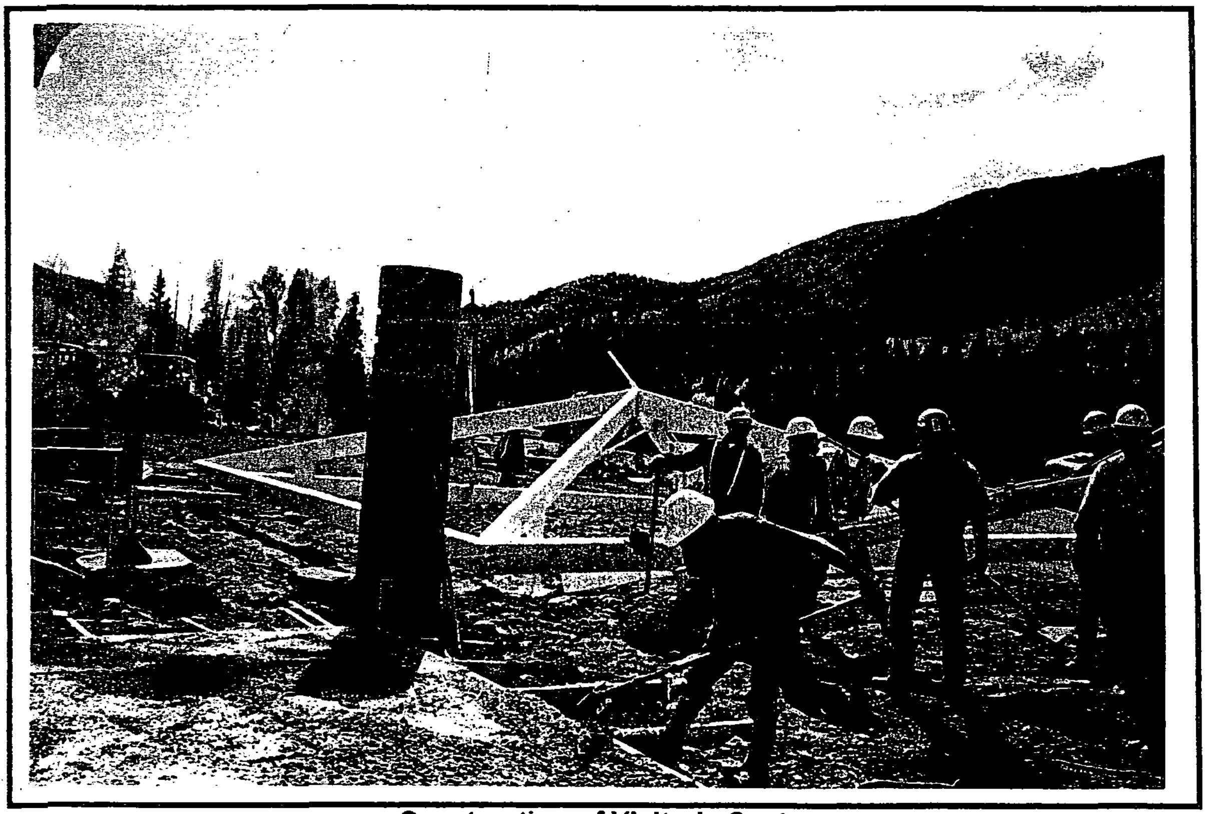
View Looking South Along R.R. Grade - Revetment Excavation Along Dolores River



Excavation for Run-on Ditch - East Side of Columbia Tailings

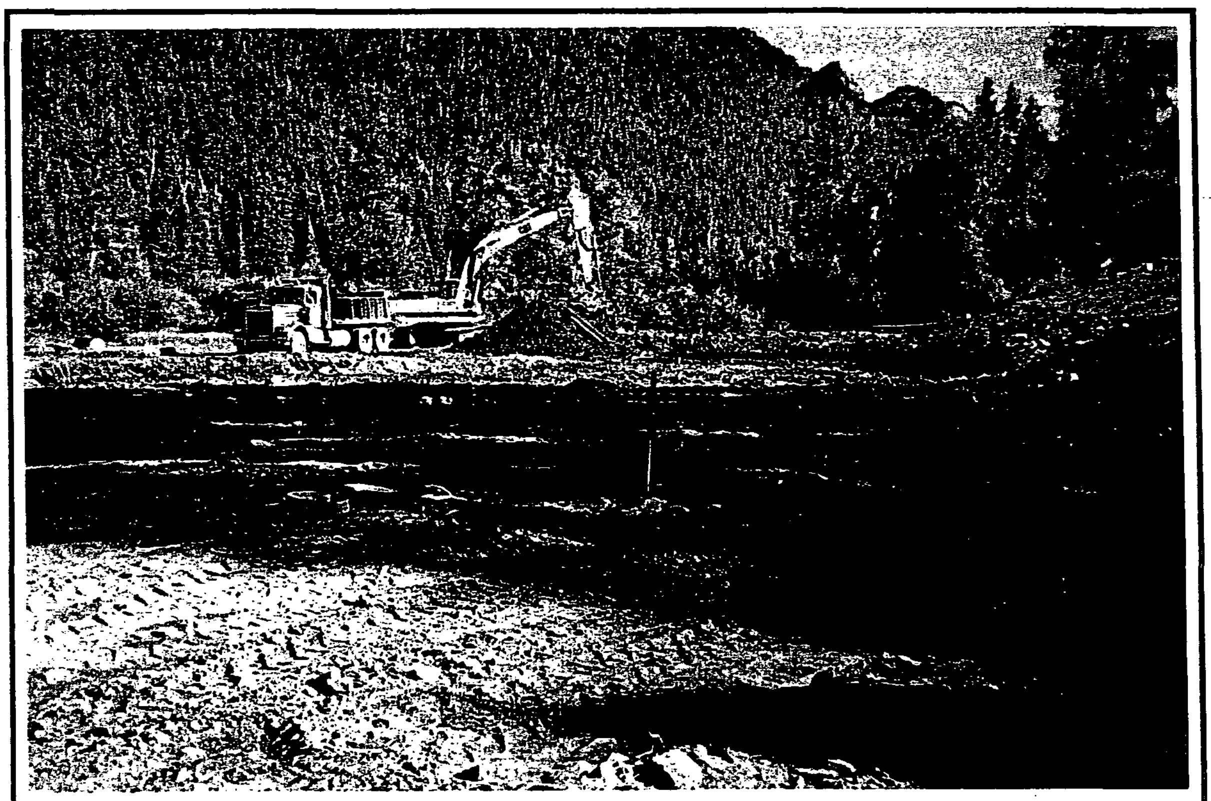


Hauling and Placing Mine Waste at Columbia Tailings

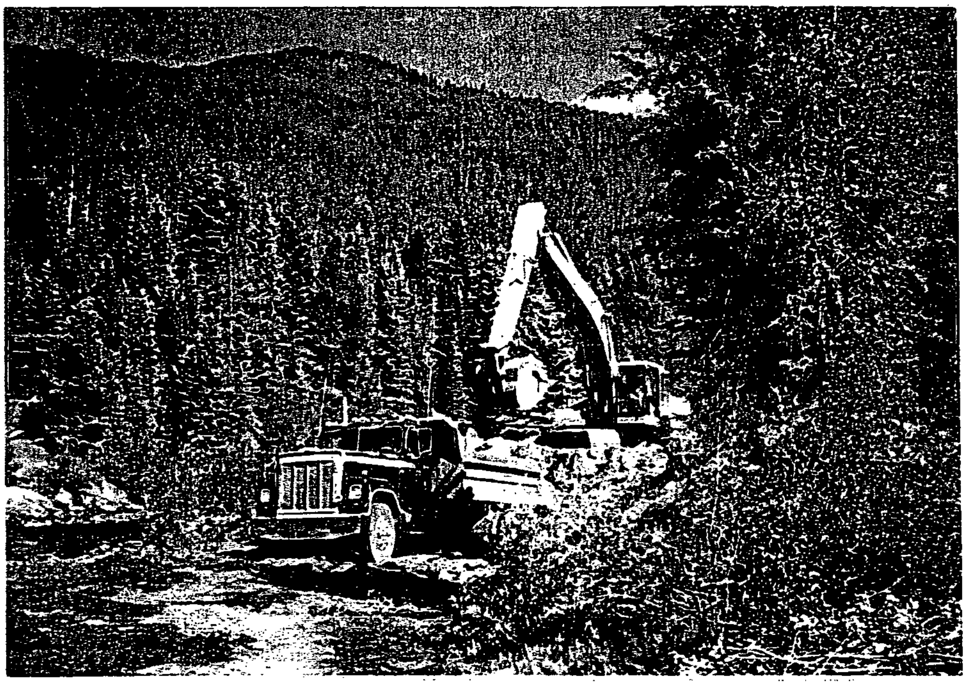


Construction of Visitor's Center

Trackhoe Removing Tailings



Loading Materials for Haul to Columbia Tailings



Shamrock Material being Loaded for Haul to Columbia

Shamrock after Soil Cover Placement

4.0 Silver Swan Mine Area

4.1 General

The Silver Swan Mine adit and waste rock piles are located along the Dolores River about ½ mile south of Rico. Pyrite and galena bearing materials are present in the mine waste rock piles that surround the mine adit. Water from the Silver Swan Mine adit was partly seeping through the mine dump and discharging into the Dolores River.

4.2 Permit

The VCRA application dated February 13, 1996 and supplemental information to the application dated March 19, 1996 were approved by the CDPHE on March 20, 1996. The CDPHE approval stated that the VCUP would meet a degree of cleanup and control of hazardous substances such that the property does not present an unacceptable risk to human health or the environment based on the property's proposed use as an open space. The approved VCUP remedial design for the Silver Swan Mine Site involves shaping of waste rock outslopes to control erosion, consolidation of waste rock materials, removal of waste rock from the active river channel, grade the Site to route offsite surface water around the wastes for runon control, and surface adjustments and compaction to shed rainfall and snowmelt from the wastes piles to control erosion and limit infiltration. The VCUP also calls for providing erosion protection through revegetation and rock covers. The existing adit discharge will be intercepted in an excavated lined trench in the adit area and routed through existing wetlands systems for passive treatment.

4.3 Geohazards

As expected in the VCUP application, no substantive engineering geologic or geotechnical issues were encountered associated with the work to implement the remedial design for the Silver Swan Mine. No slope failure problems were experienced during the materials movement and waste pile grading and contouring. Dikes constructed across wetland area did possess saturated weak foundation conditions, however, soil was placed until the wet area materials were displaced and a firm working surface was obtained. River flows did not constitute any excavation problems above those expected.

4.4 Site Access

Access to the Silver Swan was by existing roads and by a Ford type crossing over the Dolores River. Two 24" diameter CMP and six 8" diameter CMP culverts were used to pass the river's flow and an access road was built of soil over the culverts for heavy equipment access. This road and crossing were kept to the minimum safe size to reduce local disturbance. The existing roads were improved for heavy equipment access to the work areas. All roads were maintained and left in as good or better condition than existed prior to their use on this project. The Ford crossing was removed and the area returned to its pre-crossing condition. The access to the Site was completed in compliance with the COE 404 permit notification, Colorado Stormwater and USFS Road Use and Special Use Permits.

4.5 Construction Site Controls

Controls were implemented during construction to address requirements of applicable federal, state or local permits, codes or regulations. The construction contractor was responsible for supplying a pre-excavation Construction Plan for ARCO's approval prior to commencing work operation. Work was completed to comply with COE requirements for wetlands and State of Colorado Discharge Permit System Stormwater. All construction and specifications employed appropriate Best Management Practices to protect the Dolores River from sedimentation during remedial activities. The Dolores River banks were armored as needed for control of erosional losses during fording of the river. Temporary berms to control runoff to the Dolores River were constructed in work areas. Silt fencing and hay bales were used as barriers to sediment migration into the Dolores River during excavation activities. Also, construction activities were conducted in a manner to preserve existing vegetation buffers in the work areas in compliance with the Stormwater Management Plan. Runoff water was retained from disturbed areas prior to allowing discharge into the Dolores River. Strict precautions to avoid dust and excavation spillage during operations were followed by the use of water spray and control of load heaping on haul units.

The onsite construction activities were conducted in strict compliance with the Site Specific Safety and Health Plan, the Site Pre-Excavation Construction Plan and applicable permits for the work area or access roads.

4.6 Hydraulic Controls

4.6.1 Runon

The runon generated from rainfall or snowmelt up gradient of the Site is directed away from the Silver Swan Mine's reclaimed areas by a 250 linear foot lined runon ditch. The runon ditch was excavated into the reconfigured waste pile along the western boundary of the Site. The ditch is constructed of a combination of half pipe and open trapezoidal channel that is lined. The open channel liner consists of 6 inches of riprap, 6 inches of riprap bedding, textured liner (HDPE), and 6 inches of liner bedding. The ditch middle reach was constructed with 18" diameter half pipe 16 gauge CMP. The CMP was anchored by 2" x 2" x 1/4" angle iron driven into the ground and welded to the CMP.

The adit interception channel was constructed using a "v" notch design and lined with 12 inches of bedding with an intermediate textured liner. A 6 inch cap of Type B riprap was placed as the uppermost layer within the channel. This channel serves as a drainage for adit water and also directs runon from the west away from the consolidated waste rock pile into the existing wetlands. Figure 4-1 shows the locations of the runon ditch. A 60 ft. length of 12" CMP drains the adit discharge under the access road.

4.6.2 Runoff

The top surface of the consolidated waste rock has been shaped to drain precipitation and not retain runoff on the pile surface. The surface grade is generally to the south at 3%. A portion of the runoff will be captured by the runon ditch on the west side of the Site and directed to the Dolores River. The runon and runoff ditches are sized such that peak flows for a 100 year precipitation event are drained from the Site.

4.6.3 Infiltration

Infiltration of water into the waste rock pile at the Silver Swan Mine is controlled by rerouting of adit discharge away from the reclaimed pile, reducing the surface area of the pile itself, regrading of the waste rock pile to not pond water and compaction of the waste rock top surface.

The constructed adit drainage interception channel transfers drainage away from the pile and into the adjacent existing wetlands area. The channel is constructed as described in Section 4.6.1. The rerouting of the drainage away from the waste rock pile has eliminated the infiltration of mine water into the waste rock.

The surface area of the waste pile has been reduced by 60% and therefore reduces the infiltration surface available. The waste rock was consolidated by relocation into the main pile of material from the Dolores River bank and along the east side of the pile.

Below the placed growth medium, 12 inches of the Silver Swan waste rock pile top surface were compacted to aid in prohibiting infiltration. With the material types encountered in the waste dumps the density that was achieved by this compaction will reduce the hydraulic conductivity. The results of compaction testing conducted on the Silver Swan Mine reconfigured surface are summarized in Section 4.11.

4.6.4 Drainage Stabilization

Waste rock material was removed from the bank of the Dolores River. This removal extended for the length of the waste pile, approximately 440 feet and was 50 feet wide on average. The removal of waste rock cleared this material from contact with the Dolores River during peak spring runoff and for flows up to the 500 year return event flood level. Flood erosion protection revetment was placed on the reconfigured outslope adjacent to the Dolores River. The revetment consisted of Type A riprap placed 24 ft. deep over a 0.5 ft. thick Type E bedding over 0.5 ft. of Type E bedding. This removal was in compliance with ARCO's Army Corps of Engineers Nation Wide Permit 38 Notification, the Colorado Stormwater Permit and the VCUP.

4.7 Waste Materials

4.7.1 Consolidation

The waste rock material at the Silver Swan Mine extended around the Site and down into the Dolores River. A total of 1.8 acres were originally occupied by the waste rock piles. In order to achieve the VCUP goals of controlled infiltration, runoff and runon control and stabilization of the drainage in this area the pile was reshaped and waste rock consolidated onto the main pile.

Waste rock was removed in layers of about 12 inches in thickness. Following removal, confirmatory sampling was conducted to detect if all tailings material had been removed. This process was repeated until confirmation sampling showed that no additional material removal was required.

Verification of waste rock removal was accomplished by collecting confirmatory samples of the underlying alluvium. Waste rock excavation was considered completed, as defined in the VCUP, when the Zinc content fell within or below the range of local natural bedrock and surficial materials. This range is 200 to 4720 ppm Zinc. The sampling of the removal areas confirms that the majority of tailings was excavated from the areas of concern. Sampling results and summaries for the Silver Swan removal are contained in Section 4.11.

The relocated waste rock was placed in lifts not exceeding 12 inches in depth. The compaction effort was accomplished by placement equipment making a minimum of one pass over the entire surface of each 12 inch lift. Tailings placed in the upper 12 inches of the top surface, but below the lime amended area, were compacted as described later in this report.

4.7.2 Surface Shaping and Slopes

The top surface of the consolidated waste rock pile drains to the south at 3%. The pile has been reconfigured with surrounding outslopes. Although the outslopes vary in length from 20 ft. to 70 ft., all are constructed to a 3h:1v geometry. The reconfigured Silver Swan waste rock pile is graded to a tolerance of $\pm$ 0.3 ft. of construction drawings and free of irregularities. Figure 4-1 shows the preexisting conditions, VCUP configuration and the as built conditions of the Silver Swan waste pile.

4.8 Erosion Protection

4.8.1 Growth Medium

Over the compacted one foot of waste rock is a 12 inch layer of uncompacted lime amended waste rock and 12 inches of soil cover to provide a suitable growth medium approximately 2 feet deep. Agricultural lime ($CaCO_3$) was applied at a rate of 25 tons/acre to the upper 12 inches of waste rock. The lime was spread evenly over the Site by mechanical methods and then incorporated. Multiple tillage passes were made to insure complete mixing of the lime into the material seed bed. The liming process was accomplished immediately following waste pile shaping to provide the greatest reaction time prior to revegetation.

Borrow soil used for plant growth was tested and identified prior to excavation. The borrow soil was obtained from the St. Louis borrow area about two miles from the Silver Swan Mine. The soil was transported by truck to the Silver Swan Mine and placed. This soil was placed on the top surface and slopes, and covers the entire areal extent of the regraded waste pile. Soil cover was also placed over the waste removal areas. Table 4.1 describes the soil cover application at the Silver Swan Mine. The traffic over the soil was kept to a minimum to avoid unnecessary compaction of the seed bed. The finished grade for the soil growth medium is $\pm$ 0.3 ft. of design and does not contain irregularities.

Table 4.1
Silver Swan
Agricultural Lime and Cover Material Application Rates

SITE	LIME APPLICATION RATE FOR WASTE ROCK	SOIL COVER APPLICATION RATE
Silver Swan East		
Removal area on east river bank.	No lime.	Area of coarse gravel and cobble - covered with 3" - 6". Slope from R.R. grade to flat area - covered with 3" - 6".
Silver Swan West		
Main Pile	25 tons/acre (.14" thick) Amended 12" deep.	12" of processed borrow soil (-3/4").
Removal area to north of main pile. (Currently cobbles and coarse gravel).	No lime.	3"- 6" of processed borrow soil (-3/4").
Waste rock area between north toe (of main pile) and wetlands dike.	25 tons/acre (.14" thick) Amended 12" deep.	12" soil: 6" of unprocessed borrow and 6" of processed borrow soil.

4.8.2 Revegetation

All seed was applied using hydroseeding methods due to wet surface conditions and time constraints. Table 4.2 contains the seed mixtures and application rates. The hydroseeding and fertilization sequence of activity completed is as shown on Table 4.3. Mulch was also spread by hydro application methods and held in place by tacking agents.

Table 4.2
Seed Mixtures and Application Rates

Type A (1)
General Seed Mixture

Species	Preferred Variety(s)	Rate (lbs./acre) Planted (broadcast)	PLS (seeded/acre)
Big bluegrass Poa ampla	Sherman	0.50	458,500
Mountain brome Bromus carinatus	Bromar	8.00	496,000
Slender wheatgrass Agropyron trachycaulum	Primar, San Luis	3.00	480,000
Streambank wheatgrass Agropyron riparium	Sodar	3.00	480,000
Birdsfoot trefoil Lotus corniculatus	Empire	1.00	410,000
Lewis flax Linum lewisii	Apar	2.00	570,000
Rocky Mountain penstemon Penstemon strictus	Bandera	1.00	592,000
Cicer milkvetch Astragalus cicer	Lutana, Monarch	1.50	290,000
	Totals	**20.00**	**3,776,500 (approx. 87 seeds per square foot)**

(1) Type A applied on entire surface of consolidated waste rock pile and west sideslope of railroad grade at east waste rock removal area.

Type B (2)
Sideslope Stabilization Mixture

Species	Preferred Variety(s)	Rate (lbs./acre) Planted (broadcast)	PLS (seeded/acre)
Big bluegrass Poa ampla	Park	0.50	1,100,000
Mountain brome Bromus carinatus	Bromar	15.00	975,000
Slender wheatgrass Agropyron trachycaulum	Primar, San Luis	6.00	960,000
Streambank wheatgrass Agropyron riparium	Sodar	6.00	960,000
Cicer milkvetch Astragalus cicer	Lutana, Monarch	1.50	290,000
	Totals	**29.00**	**4,285,000 (approx. 98 seeds per square foot)**

Type D (3)
(Wetland Planting Mixture)

Species	Preferred Variety(s)	Rate (lbs./acre) Planted (broadcast)	PLS (seeded/acre)
Redtop (FACW) Agrostis alba	Any	0.50	2,495,000
Red fescue (FAC) Festuca rubra	Any	3.00	1,845,000
Tall (Kentucky) fescue (FACW-) Festuca arundinaceae	Any	5.00	1,135,000
	Totals	**8.25**	**5,475,000 (approx. 126 seeds per square foot)**

(2) Type B applied on hillside slope along runon/runoff ditch.
(3) Type D applied on all removal areas and area disturbed to access wetland dike construction area.

Table 4.3
Silver Swan Mine Area
Revegetation Sequence

Item	Seed Bed Preparation	Fertilizer	Seed	Mulch
Period	Prior to fertilization and seeding.	Concurrent with seeding.	After September 30th, immediately following final seed bed preparation.	Immediately following seeding.
Method	Mechanical scarification of soil.	Combined with hydroseeding, liquid fertilizer mixture.	Hydroseeding on all areas.	Hydromulch - 1500 lbs./acre, all slopes. Slurry pH> 3.5.
Equipment	Disc or rippers pulled by tractor.	Mobile hydroseeding equipment.	Mobile hydroseeding with spray and tank equipment.	
Discing/Raking	Disc or rip to 12 inch depth maximum.			May disc to crimp hay/straw mulch.
Other	Insure adequate seed bed without hard surface resistant to seed placement.	Nutrient application applies to all sites: Nitrogen (lb./acre): 40 Phosphate (lb./acre): 60 Potash (lb./acre): 40	Seed depth = 1/4" to 1/2" Spacing = 6" Type A General seed mix (<3:1) B Side slope mix (>3:1) D Wetland mix	Purpose: twofold: 1. Conserve water 2. Deter erosion

4.8.3 Riprap

Rock erosion protection was placed in areas where runoff, runon and drainage way flows were considered to be highly erosive. Riprap design gradations types, rock covers and bedding are shown on Table 4.4 by Type.

Table 4.4
Riprap, Rock Covers and Bedding

		Percent Passing					
Type	**Description**	**100**	**85**	**50**	**30**	**15**	**0**
A	Riprap	1.7-2.4'	-	1.4'-1.6'	1.2'	0.9'	0.8'
B	Riprap	Larger Rock Material Generated By Borrow Processing					
C	Riprap	0.9-1.2'	-	0.7-0.8'	0.6'	0.5-0.65'	0.4
D	Riprap/Bedding	3.0-8.0"	3.0-6.0"	-	-	0.75"-1.5"	0"-0.5"
E	Filter Material	2.0"	0.5-1.5"	-	-	0.5-0.65mm	0.6mm

A riprap revetment was placed and buried along the toe of the east slope of the waste rock pile. The revetment was placed to protect the reclaimed waste pile from erosion scour resulting from a Dolores River 500-year return peak event flood stage. A 2 ft. freeboard was also added to the top elevation of the revetment. Figure 4-1 shows the flood protection revetment location at the Silver Swan Mine. The revetment consists of 6 inches of Type D bedding, 6 inches of Type E bedding and a 2.4 ft. thick layer of Type A riprap.

The locations of the runon and runoff ditches with erosion protection riprap are also shown in plan view on Figure 4-1. These ditches contain bedding, 60 mil HDPE textured liner and riprap to handle flows resulting from a 100 year precipitation event. These designs are discussed in detail under Section 4.6.

4.9 Passive Treatment of Mine Drainage

Mine discharge from the Silver Swan adit is directed through a ditch from the mine opening to the wetlands passive treatment area. The flow of mine adit discharge water will continue over soil types used for passive wetland treatment. Only minor modifications were made to the existing wetland system were made. A dike approximately 4 ft. in height and 5 ft. wide (top) was built to the northeast of the existing pond to provide sufficient retention capacity for settling of precipitates from the mine discharge. Bentonite was placed on the inside toe of the dike to prevent seepage between the floor of the pond and the toe of the dike.

The wetlands ponded water was isolated from the waste rock pile by relocating the waste material from the flowpath of the wetlands discharge, eliminating the adit flow into the waste rock. The one acre retention area pond was enclosed by the dike. A riprap lined spillway was contracted to regulate flow out of the pond. The dike is about 140 ft. in length and was constructed of unprocessed borrow material over the wetlands floor. An overflow spillway was constructed to allow water to pass from the retention area to the existing wetlands. A 1.2 ft. thick Type C riprap layer was placed in the overflow over 6 inches of Type D bedding and 6 inches of Type E. Figure 4-1 shows the location of the wetlands and dike.

The wetlands layout provides for an aerobic treatment step in an up gradient pond to enable oxidation precipitation of dissolved iron and to serve as a sludge storage area. The assumptions, calculations, and further description of the wetlands passive treatment is contained in the Silver Swan VCRA application submitted in February 1996.

4.10 Quantity Summary

The quantities moved for remedial action for the Silver Swan Mine area involved nine categories of materials. The total volume of material moved was 3,863 cubic yards.

Table 4.5
Silver Swan Mine Area
Relocated Materials, Riprap and Bedding

Activity	Material Type	Units	Quantities
Relocated Waste Rock	***	CY	1,100
Riprap	A	CY	608
Riprap	B	CY	63
Riprap	C	CY	15
Riprap Bedding	D	CY	133
Riprap Bedding	E	CY	133
Plant Growth Medium		CY	2,700
Textured Liner		$Yd.^2$	284
Soil Amendment	Agricultural Lime	Tons	102

4.11 Soil Testing Summary

4.11.1 Geotechnical Testing

Field soil density testing was conducted to determine compliance with the technical specifications of the construction contract. The technical specifications relating to compaction were selected to achieve various engineering objectives relating to infiltration and enhancing stability in fill materials. The applicable technical specifications required that the upper 12 inches of the waste piles below the amended material be of a compactable gradation, and attain 95% of Standard Proctor maximum dry density (or 90% of maximum Providence index density for soils with little or no fines). Table 4.6 summarizes the field soil moisture/density tests conducted for the Argentine Tailings. Nuclear density gauges were used to obtain in-place densities for comparison to laboratory generated Proctor or Providence mold laboratory density tests as appropriate for a given soil. Where moisture/density tests were deficient, footnotes in Table 4.6 indicates the action taken by the field engineer, e.g. - recompaction of the affected area or in cases where additional compaction or replacement of fill materials would not have provided any additional benefits to the long-term performance of the fill with respect to design objectives, no action was directed. Laboratory and field tests were performed and results approved by ARCO. Tests were conducted according to the following standards:

ASTM Method	Description:
Field Tests:	
D-2922	Density of Soil and Soil-Aggregate in Place by Nuclear Methods
Laboratory Tests:	
D-422	Sieve Analysis
D-698	Moisture Density Relationships (5.5 lb. hammer)
D-4253	Modified Providence Moisture Density Relationships

Table 4.6 summarizes the results of field tests.

Table 4.6
Silver Swan Mine
Field Soil Testing Summary

Date	Test No.	Location	Density	Moisture	Proctor No.	Maximum Density	Optimum Moisture	Percent Compaction	Notes	% Compaction Required	Percent +\- Moisture
22-Aug-96	SS-NU-01	Wetlands Dike	114.6	16.6%	Estimate	125	***	92%		90%	
"	SS-NU-02		99.4	17.9%	"	125	***	80%	(1)	90%	
"	SS-NU-03		99.4	16.5%	"	125	***	80%	(1)	90%	
"	SS-NU-04		108.4	18.6%	"	125	***	87%	(1)	90%	
"	SS-NU-05		109.9	17.2%	"	125	***	88%	(1)	90%	
"	SS-NU-06		110.3	16.8%	"	125	***	88%	(1)	90%	
5-Sep-96	SS-NU-07	Main Pile Pre-Amendment	108.2	13.1%	EF-09-MP-01	128	***	85%	(2)	90%	
"	SS-NU-08		113.9	12.5%	"	128	***	89%	(2)	90%	
"	SS-NU-09		125.2	15.5%	"	128	***	98%		90%	
"	SS-NU-10		121.0	11.3%	"	128	***	95%		90%	
"	SS-NU-11		124.8	10.1%	"	128	***	98%		90%	
"	SS-NU-12		112.8	12.1%	"	128	***	88%	(2)	90%	
"	SS-NU-13		119.8	12.9%	"	128	***	94%		90%	
12-Sep-96	SS-NU-14	Runon-Runoff Ditch Liner Bedding	106.3	13.8%	EF-10-SP-01	129	12%	82%	(3)	90%	1.8%
"	SS-NU-15		98.1	15.4%	"	129	12%	76%	(3)	90%	3.4%
"	SS-NU-16		102.9	14.8%	"	129	12%	80%	(3)	90%	2.8%
"	SS-NU-17		107.4	15.6%	"	129	12%	83%	(3)	90%	3.6%
16-Sep-96	SS-NU-18	Runon ditch Pipe Bedding	103.6	12.9%	EF-10-SP-01	129	12%	80%	(3)	90%	0.9%
16-Sep-96	SS-NU-19		108.9	14.9%	"	129	12%	84%	(3)	90%	2.9%

*** Modified Providence Tests and estimated maximum densities did not generate an optimum moisture.

(1.) Low densities were the result of saturated materials procured from the Cayton Campground borrow area. Subgrade was reworked and additional compaction effort was completed.

(2.) Contractor provided additional compaction effort in this area after nuclear gauge testing. This effort was considered sufficient.

(3.) Low densities were the result of saturated materials procured from the St. Louis borrow area. Subgrade was reworked and additional compaction effort was completed.

* Soil testing provided by ESA, Inc., Fort Collins, CO.

4.11.2 Confirmatory Testing

Confirmatory testing was performed at each location where specific removal of mine waste rock or mill tailings was specified in the Voluntary Cleanup Plan (VCUP). Based on soil investigations within and surrounding the Town of Rico, Zinc levels range from 200 to 4720 ppm. The cleanup level was set at a maximum of 4720 ppm for testing of subgrade after the removal of materials. Sample results above the limit resulted in further removal and sampling. Table 4.7 summarizes the confirmatory sampling results. Final samples indicate the cleanup was successful. The comprehensive report of confirmatory testing on the Rico Project is contained in the Appendix.

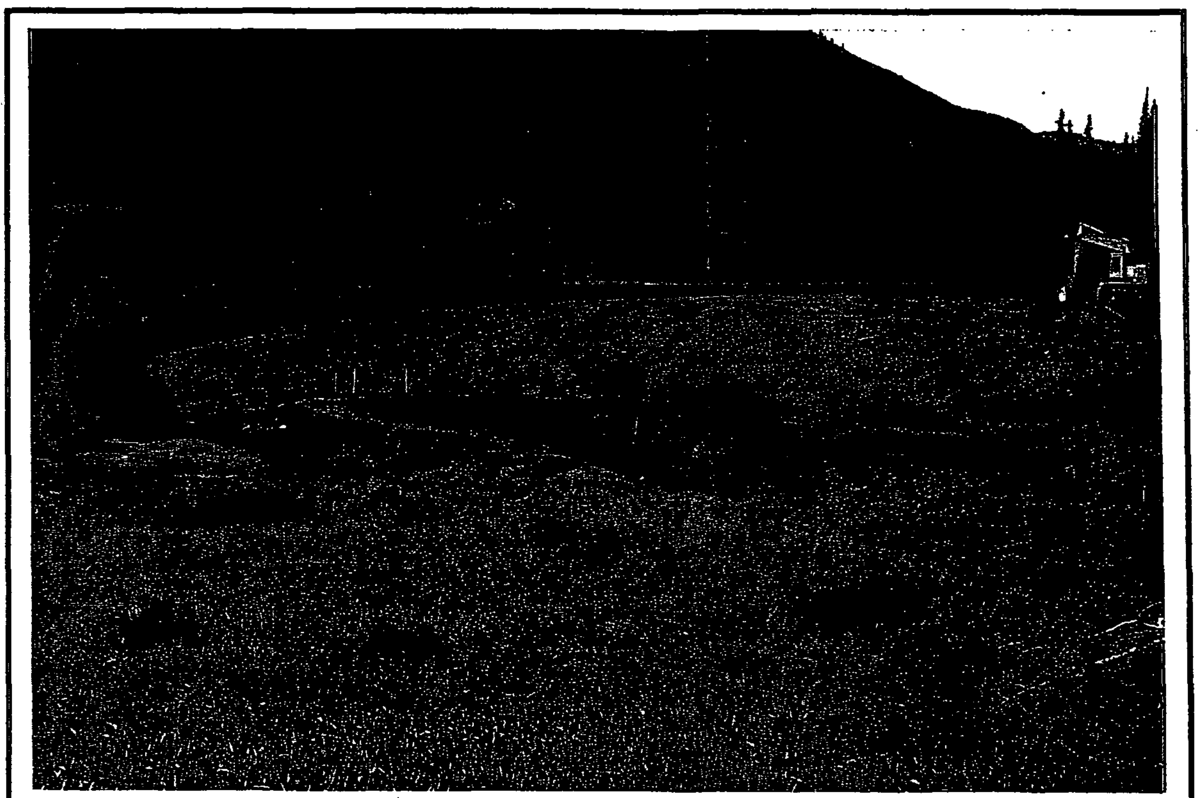
Table 4.7
Silver Swan Mine Area
Confirmatory Testing

Removal Site	Sample ID	Zinc (ppm)	Sample Type
Silver Swan east bank	EX-SSE-01	2,030	Composite
Silver Swan west bank	EX-SSW-01	788	Composite
Silver Swan west bank	EX-SSW-02	1,640	Composite

5.12 As Built Drawings

4.13 Photographs

Dozer and Trackhoe Reconfiguring Mine Waste



Reconfigured Waste Pile with Wetlands Dike in Foreground

5.0 Santa Cruz Mine Area

5.1 General

The Santa Cruz Mine Area and adit are located on the west side of the Dolores River south of Rico, Colorado. The Santa Cruz, Iron Clad and Rico Boy Mines are all former underground operations. This Site occupies approximately five acres and consists of mine openings, waste rock piles and some scattered debris. The Site is adjacent to a wetland area associated with the Dolores River.

The Site is made up of waste rock piles produced from the mines. Debris associated with the former mining activity and several buildings exist in the northern position of the Site. The southwestern portion of the waste rock was placed against the nearby hillside slope. Mine water from the Santa Cruz, Iron Clad and Rico Boy adits and was flowing on the surface onto the nearby waste materials and eventually into the adjacent wetlands.

5.2 Permit

The VCRA application dated March 8, 1996 and supplements to the application dated April 16, 1996 were approved by the CDPHE on April 19, 1996. The CDPHE approval stated that the VCUP would meet a degree of clean up and control of hazardous substances such that the property does not present an unacceptable risk to human health and the environment based on the property's proposed use as an open space. The approved VCUP remedial design for the Santa Cruz Mine Area involves reconfiguring the existing waste pile, relocation of wastes for stabilization along the Dolores River construction runon and runoff control features, and compaction and treatment of waste materials to reduce infiltration. Erosion protection of the Site is addressed in the VCUP by providing a reclamation cover consisting of plant growth medium with amendments and seeding. The adit discharge waters are to be captured and directed through the mine area by a lined interception ditch. A wetlands dike was constructed to enhance the existing system for passive treatment of discharge waters.

5.3 Geohazards

As expected in the VCUP application, no substantive engineering geologic or geotechnical issues were encountered during the work to implement the remedial design for the Santa Cruz Mine. No slope failure problems were experienced during the materials movement and waste pile grading and contouring. The dikes conditions, however, soil was placed until the wet area materials were displaced and a firm working surface was obtained. The Dolores River flows did not constitute any excavation problems above those expected.

5.4 Site Access

Access to the Santa Cruz was by existing roads that pass through west Rico. An existing USFS bridge was used to access the Site with light equipment and service vehicles. A Road Use Permit and a Special Use Permit were obtained from the USFS and upgrades were made to the bridge during usage. Both approaches to the bridge were paved. Roads used for access were maintained and left in as good or better condition than existed prior to their use on this project. Road access use information was recorded and maintained as required by the USFS permits.

5.5 Construction Site Controls

Controls were implemented during construction to address requirements of applicable federal, state or local permits, codes or regulations. Work was completed to comply with COE notice requirements for wetlands and State of Colorado Discharge Permit System for Stormwater. The beaver pond on the east side of the main pile was drained prior to construction in compliance with Colorado Discharge Permit System Minimal Discharge Permit. All construction work and specifications employed appropriate Best Management Practices to protect the Dolores River and wetlands from sedimentation during remedial activities. The Dolores River banks were protected as needed for control of erosional losses during work near the Dolores River. Silt fencing and hay bales were used as barriers to sediment migration to the Dolores River during excavation activities. Sediment traps and ponds existing in the area were used to also control sediment movement. Also, construction activities were conducted in a manner to preserve existing vegetation buffers in the work area in compliance with the Stormwater Management Plan.

Water was retained from disturbed areas prior to allowing discharge into the Dolores River. Strict precautions to avoid dust and excavation spillage during operations were followed by the use of water spray and control of load heaping on haul units.

The onsite construction activities were conducted in strict compliance with the Site Specific Safety and Health Plan and the Site Pre-Excavation Construction Plan.

5.6 Hydraulic Controls

5.6.1 Runon

Runon controls include the installation of a lined ditch about 200 ft. long to intercept upgradient rainfall runoff and snowmelt. The lined ditches, drop structures, and energy dissipation features have been placed to direct expected flows away from the reshaped waste rock pile. The runon interception ditch was constructed between the reconfigured waste pile and the natural hillside west of the mine area. The alignment of the runon ditch is shown in Figure 5-1. The runon ditch is constructed of a combination of corrugated metal half pipe, a riprap lined stilling basin and a full pipe beneath the relocated access road. The main portion of the runon ditch is lined with 18 inch diameter, 16 gauge CMP half pipe. The CMP was anchored by 2" x 2" x 1/4" angle iron set into the graded fill. The grade of the ditch is about 33% and spills into a riprap stilling basin composed of 2 ft. of Type A riprap over 6 inches of Type D and 6 inches of Type E riprap. The stilling basin is drained under the relocated access road by a 15 inch diameter reinforced concrete pile for a distance of approximately 30 feet. Type C riprap was placed 4 feet on each side of the ditch at the end of the drainage. Water is retained in the bermed area of the wetlands to allow for settling. An overflow spillway was constructed to allow water to pass from the retention area to the existing wetlands along the Dolores River corridor. The overflow is constructed of 2.4 ft. of Type A riprap, underlayed by 6 inches of Type D and 6 inches of Type E bedding.

Some runon will be captured by the adit interception ditch that drains the Rico Boy and Santa Cruz adit from the hill area to the west. The construction of the adit interception ditch consists of an open "v" notch design channel with 12 inches of soil bedding with an intermediate textured liner. A 6 inch layer of Type B riprap was placed as the uppermost portion within the ditch. The adit interception ditch drains from north to south and passes along the toe of the reshaped waste rock pile. Runon resulting from the west enters the adit interception ditch and is directed into the existing wetlands.

5.6.2 Runoff

The surface of the consolidated waste rock has been contoured and graded to drain precipitation and not retain runoff on the pile surface. The waste rock reconfiguration blends into the adjacent land form. The outslopes of the waste rock have been graded to 3h:1v. The slope configuration and adit interception ditch convey runoff flows away from the Site in a controlled manner. The adit interception ditch drains runoff from the mine waste pile area at between 1% and 8% within a riprap lined channel. Figure 5-1 depicts the runoff patterns and runoff ditch locations and spillway areas.

5.6.3 Infiltration

Infiltration of water into the waste rock pile at the Santa Cruz Mine is controlled by rerouting of adit discharge away from the reclaimed pile, reducing the surface area of the pile itself, regrading of the waste rock pile to not pond water and compaction of the waste rock top surface. A new access road embankment was constructed of clean fill installed along the east toe of the consolidated waste rock pile to prevent direct contact of the wetland surface water with waste rock.

The discharge from the Santa Cruz adit and the Rico Boy adit is estimated at an average 60 gpm from the mine openings. This discharge is collected by a constructed adit interception channel that transfers the discharge waters away from the waste pile and into the adjacent existing wetlands. The channel is constructed as described in Section 5.6.1. The rerouting of the discharge away from the waste rock pile will be of significant impact for reducing infiltration of mine water. The adit discharge to the waste rock in the mine area has been directly eliminated.

The surface area of the waste rock pile has been reduced by 73% and thereby reducing the infiltration surface available. The waste rock was consolidated by removal of mining waste rock from the area directly east of the mine adits. This material occupied about 1.6 acres and was placed on the main mining waste pile existing south of the adits. This reduction in surface area will decrease the total infiltration from snowmelt and direct rainfall into the waste rock. The surface of the consolidated waste was contoured to drain precipitation occurring on the waste pile and avoid impeding flow and retention and ponding of water on the reconfigured pile.

The upper 12 inches of top surface and 3h:1v outslopes of the Santa Cruz waste rock pile were compacted prior to placement of growth medium. The compaction of this material will aid in prohibiting infiltration into the waste pile. With the material types encountered in the waste dumps, the density that is achieved by this compaction will reduce the hydraulic conductivity at the surface of the waste pile. Moisture was controlled to ± 2 % during the compactive effort.

The results of compaction testing conducted on the Santa Cruz Mine reconfigured surface are summarized in Section 5.11.1.

5.6.4 Drainage Stabilization

Approximately 5,200 cubic yards of mine waste rock material were removed from the Dolores River corridor area near the mine. This removal extended for the length of the waste pile, approximately 500 feet and was 100 feet wide on average. The removal of waste rock cleared this material from contact with the Dolores River during peak flood stage resulting from 100 year flood events. The removal of this material was in compliance with ARCO's Army Corps of Engineers Nationwide Permit No. 38 Notification, the Colorado Stormwater Permit in addition to the VCUP. The removal of this waste creates an added 0.6 acres of area available for wetlands adjacent to the reclaimed mine area. Figure 5-1 is a plan view of the completed work and shows the newly created surface in the drainage area.

5.7 Waste Materials

5.7.1 Consolidation

The waste rock material at the Santa Cruz Mine extended around the Site and down into the Dolores River wetlands area. A total of 2.2 acres were occupied by the existing waste rock piles and reduced by 0.6 acres after consolidation activities. In order to achieve the VCUP goals of controlled infiltration, runoff and runon control and stabilization of the drainage in this area the pile was reshaped and the waste rock consolidated. Approximately 5,200 cubic yards of waste rock was relocated and shaped to meet the lines and grades required by the VCUP. This work was accomplished using bulldozers, wheel loaders and highway type haul trucks. The removal location of the waste rock and final graded surface of the removal areas are shown on Figure 5-1.

Waste rock was removed in layers of about 12 inches in thickness. Following removal, confirmatory sampling was conducted to detect if all waste material had been removed. This process was repeated until conformation sampling showed that no additional material removal was required.

Verification of waste rock removal was accomplished by collecting confirmatory samples of the underlying Dolores River alluvium. Waste rock excavation was considered completed, as defined in the VCUP, when the Zinc content of underlying soils within fell within or below the range of local natural bedrock and surficial materials. This range is 200 to 4720 ppm Zinc. The sampling of the removal areas confirms that the majority of waste rock was excavated from the areas of concern. Sampling results and summaries are contained in Section 5.11.

The relocated waste rock was placed onto the main pile in lifts not exceeding 12 inches in depth and compacted. The compactive effort was accomplished by placement equipment making a minimum of one pass over the entire surface of each 12 inch lift.

5.7.2 Surface Shaping and Slopes

The small area of top surface on the consolidated waste rock pile drains to the south at 3%. The pile has been reconfigured for drainage erosion control and to blend adjacent land forms. The outslopes vary in length from about 50 ft. to 140 ft., all are constructed to a 3h:1v geometry. The reconfigured Santa Cruz waste rock pile is graded to a tolerance of ± 0.3 ft. of construction drawings and free of irregularities. Surface shaping was accomplished using the same type of heavy equipment as the waste rock consolidation. Figure 5-1 shows the pre-existing conditions, VCUP configuration and the as built conditions of the Santa Cruz Mine waste rock pile. One foot of unprocessed borrow from the St. Louis Borrow was placed at the wetlands areas where waste rock was removed as shown on Figure 5-1.

The upper 12 inches of the waste rock on the surface of the waste pile was compacted. The compact test summary and field tests are contained in Section 5.11.1 of this report.

5.8 Erosion Protection

5.8.1 Growth Medium

The top surface material of the reshaped Santa Cruz was sampled to evaluate agricultural lime requirements. Areas requiring lime amendments were identified in the field. Over the compacted one foot of waste material, a 12 inch layer of loose waste amended with lime was placed to provide a suitable growth medium. Over the top of the lime amended layer is a 12 inch layer of soil resulting in total vegetation growth zone of approximately 2 feet deep. The lime was applied at a rate of 80 tons/acre for the main pile and 280 tons/acre for the northeast area of the pile in the upper 12 inches of waste. No lime was required in the northeast removal area or the access road. Table 5.1 shows the lime application rates for the Santa Cruz Mine Area. The lime was spread evenly over the Site by mechanical methods then incorporated. Multiple tillage passes were made to insure complete mixing of the lime into the material. The liming process was accomplished immediately following waste pile shaping to provide the greatest reaction time prior to revegetation.

Borrow soil used for plant growth was tested and identified prior to excavation. The borrow soil was obtained from the St. Louis borrow area 2 miles from the Santa Cruz Mine. The soil was transported by truck to the Santa Cruz and placed over the top of the lime amended material to a depth 12 inches. This soil was placed on the top surface and slopes and covered the entire areal extent of the regraded waste pile. The removal area northeast of the waste rock pile was covered with approximately 12 inches of unprocessed borrow. The traffic over the soil was kept to a minimum to avoid unnecessary compaction of the seed bed. The finished grade for the soil growth medium is $\pm$ 0.3 ft. of design and does not contain irregularities.

Table 5.1
Santa Cruz Mine Site
Lime Application Rates

SITE	LIME APPLICATION RATE FOR WASTE ROCK	SOIL COVER APPLICATION RATE
Santa Cruz		
Northeast removal area	No lime	12" unprocessed borrow soil.
Access road slope on east side.	No lime	12" of unprocessed borrow soil.
Main Pile	80 tons/acre (0.46 in. thick) Amend 12"	12" processed soil (-3/4").
Small isolated area	280 tons/acre (1.6 in. thick) Amended 12" on N.E. area of pile (as directed by ARCO)	12" processed soil (-3/4").

5.8.2 Revegetation

All seed was applied by hydrology methods due to wet surface conditions and time constraints. Table 5.2 contains seed mixtures and applications used at the Santa Cruz Mine Site. The hydroseeding and fertilization sequence of activity completed is as shown on Table 5.3. Mulch was also spread by hydro application methods and held in place by tacking agents.

Table 5.2
Santa Cruz Mine Area
Seed Mixtures and Application Rates

Type A (1)
General Seed Mixture

Species	Preferred Variety(s)	Rate (lbs./acre) Planted (broadcast)	PLS (seeded/acre)
Big bluegrass Poa ampla	Sherman	0.50	458,500
Mountain brome Bromus carinatus	Bromar	8.00	496,000
Slender wheatgrass Agropyron trachycaulum	Primar, San Luis	3.00	480,000
Streambank wheatgrass Agropyron riparium	Sodar	3.00	480,000
Birdsfoot trefoil Lotus corniculatus	Empire	1.00	410,000
Lewis flax Linum lewisii	Apar	2.00	570,000
Rocky Mountain penstemon Penstemon strictus	Bandera	1.00	592,000
Cicer milkvetch Astragalus cicer	Lutana, Monarch	1.50	290,000
	Totals	**20.00**	**3,776,500 (approx. 87 seeds per square foot)**

(1) Type A applied on waste rock pile area.

Type B (2)
Sideslope Stabilization Mixture

Species	Preferred Variety(s)	Rate (lbs./acre) Planted (broadcast)	PLS (seeded/acre)
Big bluegrass Poa ampla	Park	0.50	1,100,000
Mountain brome Bromus carinatus	Bromar	15.00	975,000
Slender wheatgrass Agropyron trachycaulum	Primar, San Luis	6.00	950,000
Streambank wheatgrass Agropyron riparium	Sodar	6.00	960,000
Cicer milkvetch Astragalus cicer	Lutana, Monarch	1.50	290,000
—	**Totals**	**29.00**	**4,235,000 (approx. 98 seeds per square foot)**

(2) Type B applied on hillsides slopes along the runon interception ditch, disturbed hillside above Santa Cruz portal, and the outslope of the new access road embankment.

Table 5.3
Santa Cruz Mine Site
Revegetation Sequence

Item	Seed Bed Preparation	Fertilizer	Seed	Mulch
Period	Prior to fertilization and seeding.	Concurrent with seeding.	After September 30th, immediately following final seed bed preparation.	Immediately following seeding.
Method	Mechanical scarification of soil.	Combined with hydroseeding equipment.	Hydroseeding on all areas.	Hydromulch - 1500 lbs./acre, all slope areas. Slurry pH>3.5.
Equipment	Disc or rippers pulled by tractor.		Mobile hydroseeding with spray and tank equipment.	
Discing/Raking	Disc or rip to 12 inch depth maximum.			
Other	Insure adequate seed bed without hard surface resistant to seed placement.	Nutrient application applies to all sites: Nitrogen (lb./acre) 40 Phosphate (lb./acre) 60 Potash (lb./acre) 40	<u>Type</u> A General seed mix (<3:1) B Side slope mix (>3:1) D Wetland mix	Purpose: twofold: 1. Conserve water 2. Deter erosion

5.8.3 Riprap

Riprap erosion protection was placed where runoff and runon drainage occurs. Riprap types, rock covers and bedding are shown on Table 5.4.

Table 5.4
Santa Cruz Mine Site
Riprap and Bedding

		Percent Passing					
Type	**Description**	**100**	**85**	**50**	**30**	**15**	**0**
A	Riprap	1.7-2.4'	-	1.4'-1.6'	1.2'	0.9'	0.8'
B	Riprap	Larger Rock Material Generated By Borrow Processing					
C	Riprap	0.9-1.2'	-	0.7-0.8'	0.6'	0.5-0.65'	0.4
D	Riprap/Bedding	3.0-8.0"	3.0-6.0"	-	-	0.75"-1.5"	0"-0.5"
E	Filter Material	2.0"	0.5-1.5"	-	-	0.5-0.65mm	0.6mm

The runon and runoff ditch designs and erosion protection riprap are shown in plan view on Figure 5-1. These ditches contain bedding, textured liner and riprap to handle flows resulting from a 100 year precipitation event. These designs are discussed in detail under Section 5.6.

5.9 Passive Treatment of Mine Drainage

Drainage from the Santa Cruz and the Rico Boy mine adits is captured by the adit interception ditch. The ditch conveys adit flows around the consolidated waste rock pile to the south into the existing wetlands. The existing wetlands' conditions are conducive to some natural attenuation of metals. Only minor modifications of the existing wetlands in the area were made. A dike 5 ft. in height and 5 ft. wide (top) was built to the south of the waste rock and utilizes a small pond area to provide for sufficient retention capacity for settling of precipitates. The wetlands ponded water was isolated from the consolidated waste rock pile by the construction of a clean fill access road embankment around the east and south sides of the pile. Approximately 0.5 acres of retention area pond was enclosed by the dike. A riprap lined overflow was constructed to regulate flow out of the pond maintaining the 5 day retention time specified in the VCUP. The dike extends about 400 ft. and was constructed over the wetlands floor of unprocessed borrow material. Two overflow areas were constructed in the dike with a 2 ft. layer of Type A riprap placed over two 6 inch bedding layers of Types D and E material. The core of the dike consisted of 2 ft. of unprocessed borrow. Figure 5-1 shows a plan view of the dike location and overflow spillways.

The wetlands layout provides for an aerobic treatment step in an up gradient pond to enable oxidation precipitation of dissolved iron and to serve as a sludge storage area. The assumptions, calculations and further description of the wetlands passive treatment is contained in the Santa Cruz VCRA application.

5.10 Quantity Summary

The quantities moved for remedial action for the Santa Cruz Mine Area involved ten categories of materials. The total volume of material moved was 7,606 cubic yards. Table 5.5 contains the volume of materials moved by category for earthwork at the Santa Cruz Mine Site.

Table 5.5
Santa Cruz Mine Area
Relocated Materials, Riprap and Bedding

Activity	Material Type	Units	Quantities
Relocated Waste Rock	***	CY	5,200
Unprocessed Cover Soil	Borrow Soil	CY	1,100
Processed Cover Soil	-3/4" Borrow Soil	CY	2,273
Riprap	A	CY	119
Riprap	B	CY	133
Riprap	C	CY	10
Riprap Bedding	D	CY	22
Riprap Bedding	E	CY	22
Textured Liner		$Yd.^2$	794
Soil Amendment	Agricultural Lime	Tons	53

5.11 Soil Testing Summary

5.11.1 Geotechnical Testing

Field soil density testing was conducted to determine compliance with the technical specifications of the construction contract. The technical specifications relating to compaction were selected to achieve various engineering objectives relating to infiltration and enhancing stability in fill materials. The applicable technical specifications required that the upper 12 inches of the waste pile below the lime amended material be of a compactable gradation, and attain 95% of Standard Proctor maximum dry density (or 90% of maximum Providence index density for soils with little or no fines). Table 5.6 summarizes the field soil moisture/density tests conducted for the Argentine Tailings. Nuclear density gauges were used to obtain in-place densities for comparison to laboratory generated Proctor or Providence mold laboratory density tests as appropriate for a given soil. Where moisture/density tests were deficient, footnotes in Table 5.6 indicates the action taken by the field engineer, e.g. - recompaction of the affected area or in cases where additional compaction or replacement of fill materials would not have provided any additional benefits to the long-term performance of the fill with respect to design objectives, no action was directed. Laboratory and field tests were performed and results approved by ARCO. Tests were conducted according to the following standards:

ASTM Method	Description:
Field Tests:	
D-2922	Density of Soil and Soil-Aggregate in Place by Nuclear Methods
Laboratory Tests:	
D-422	Sieve Analysis
D-698	Moisture Density Relationships (5.5 lb. hammer)
D-4253	Modified Providence Moisture Density Relationships

Table 5.6 summarizes the results of field tests.

Table 5.6
Santa Cruz Mine
Field Soil Testing Summary

Date	Test No.	Location	Density	Moisture	Proctor No.	Maximum Density	Optimum Moisture	Percent Compaction	Notes	% Compaction Required	Percent +\- Moisture
9-Aug-96	SC-NU-01	Main Pile	119.8	12.9%	EF-07-MP-01	122.7	***	98%		90%	
"	SC-NU-02	Pre-Amendment	125.6	13.0%	"	122.7	***	102%		90%	
"	SC-NU-03		113.8	12.3%	"	122.7	***	93%		90%	
16-Aug-96	SC-NU-04	Main Pile	111.3	10.2%	Estimate	125	***	89%	(1)	90%	
"	SC-NU-05	Pre-Amendment	123.7	9.9%	"	125	***	99%		90%	
"	SC-NU-06		119.0	11.2%	"	125	***	95%		90%	
"	SC-NU-07		118.6	9.5%	"	125	***	95%		90%	
"	SC-NU-08		123.8	7.5%	"	125	***	99%		90%	
"	SC-NU-09		112.9	9.2%	"	125	***	90%		90%	
16-Sep-96	SC-NU-10	Runon Ditch	104.2	22.2%	EF-10-SP-01	129	12%	81%	(2)	90%	10.2%
"	SC-NU-11	Bedding	118.5	17.0%	"	129	12%	92%		90%	5.0%
"	SC-NU-12		112.8	19.0%	"	129	12%	87%	(2)	90%	7.0%
"	SC-NU-13		115.3	18.4%	"	129	12%	89%	(2)	90%	6.4%
"	SC-NU-14		114.1	15.8%	"	129	12%	88%	(2)	90%	3.8%
20-Sep-96	SC-NU-15	Adit Ditch	118.9	17.0%	EF-10-SP-01	129	12%	92%		90%	5.0%
"	SC-NU-16	Liner Bedding	120.8	16.9%	"	129	12%	94%		90%	4.9%

*** Modified Providence Tests and estimated maximum densities did not generate an optimum moisture.

(1.) The slightly substandard result was not representative of the general area and did not warrant additional compactive effort.

(2.) Low densities were the result of saturated fill materials from recent precipitation. Subgrade was reworked and additional compaction effort was completed.

* Soil testing provided by ESA, Inc., Fort Collins, CO.

5.11.2 Confirmatory Testing

Confirmatory testing was performed at each location where specific removal of mine waste rock or mill tailings was specified in the Voluntary Cleanup Plans (VCUP). Based on soil investigations within and surrounding the Town of Rico, zinc levels range from 200 to 4720 ppm. The cleanup level was set at a maximum of 4720 ppm for testing of subgrade after the removal of materials. Sample results above the limit resulted in further removal and sampling. Final samples indicate the cleanup was successful. Table 5.7 summarizes the confirmatory sampling results. The comprehensive report of confirmatory testing on the Rico Project is contained in the Appendix.

Table 5.7
Santa Cruz Mine Site
Confirmatory Testing

Removal Site	Sample ID	Zinc (ppm)	Sample Type
Santa Cruz	EX-SC-02	1,440	Composite
	EX-SC-03	2,640	Single sample
	EX-SC-04	422	Single sample